CHAPTER

16

COMMUNICATING OVER PHONE LINES

In this chapter, you will learn:

- The basics of how computers communicate with each other
- About the problems faced by systems communicating over phone lines
- How modems work and what features and protocols modems use
- How to configure a modem, using Windows 9x, Windows NT, or Windows 2000
- The features of different communications software programs and how to use one of the more popular (pcANYWHERE) programs
- How to troubleshoot modem operations
- About high-speed digital communication lines, including ISDN, DSL, and cable modem

Most personal computers today have modems. In fact, modems are almost considered standard equipment on new PCs that target the home market because of the popularity of e-mail, the Internet, and the World Wide Web, and also because telecommuting employees offer advantages to their companies. However, there is a speed ceiling on regular phone lines, which is resulting in an emphasis on the development of digital alternatives, such as ISDN and DSL—digital replacements for regular phone lines and cable modems. This chapter discusses some of the alternatives to phone lines, how they work, and what is needed on a PC to support them.

The ultimate goal of many PC users is to use their modems and phone lines to access a network, either the Internet or a private business network. However, this chapter focuses on installing and configuring modems on phone lines, and leaves the subject of networking, including accessing the Internet, for the next chapter.

COMMUNICATIONS LAYERS

The morning paper arrives filled with all the latest news; readers quickly turn to the editorial section to see what the editors are thinking today. Seldom do they stop to think about the systems, methods, people, and equipment required for that morning paper, with its interesting editorials, to arrive at the door. They probably understand that layers of systems are in place to make it possible for this single event (the arrival of the paper at your door), and many more like it, to occur. As you look at Figure 16-1, consider the systems that transport the paper to your door. News editors create the material sent to the press. Workers at the press distribution center load the papers onto trucks that carry them to distribution points in the city. Delivery people pick up the papers and use their own system to disperse them.

As you read an editorial, the news editor is communicating with you, even though you recognize that this communication is not direct (face to face) but logical, or virtual (by indirect methods). Another way of saying this is that virtual communication takes place between the editor and the reader by way of direct, or physical, communication, through systems that the two people might or might not recognize. The editor is aware of the printing process and communicates with that system, and the reader is aware of the delivery person on the bicycle and communicates with him or her. However, neither the reader nor the editor needs to be aware of, or communicate with, the other systems in the diagram.

Now think of communication in the above example in terms of layers. To transport papers, a delivery system often depends on a supporting system to make it work. For example, the distribution department depends on the truck drivers and their trucks. The truck system is dependent on the road system. If a bridge goes out, a truck can't pass over it, the truck driver cannot perform his or her duty, the person at the distribution center cannot fill an order at a distribution point, and the morning paper does not arrive. As you study communication over phone lines, remember this analogy of layers of transport systems being dependent on other layers of supporting systems. This concept is often referred to as communications layers. Four communications layers in the newspaper analogy are: the editor and reader, the distribution system, the trucking system, and the road system.

Figure 16-2 illustrates direct communication over phone lines between systems. One computer sends data to its modem, which transmits that data over phone lines to a modem on the other end, which transmits the data to a receiving computer. The figure also indicates that the mode of communication differs at different stages in the process: PC-to-modem communication is digital, but modem-to-modem communication is analog.

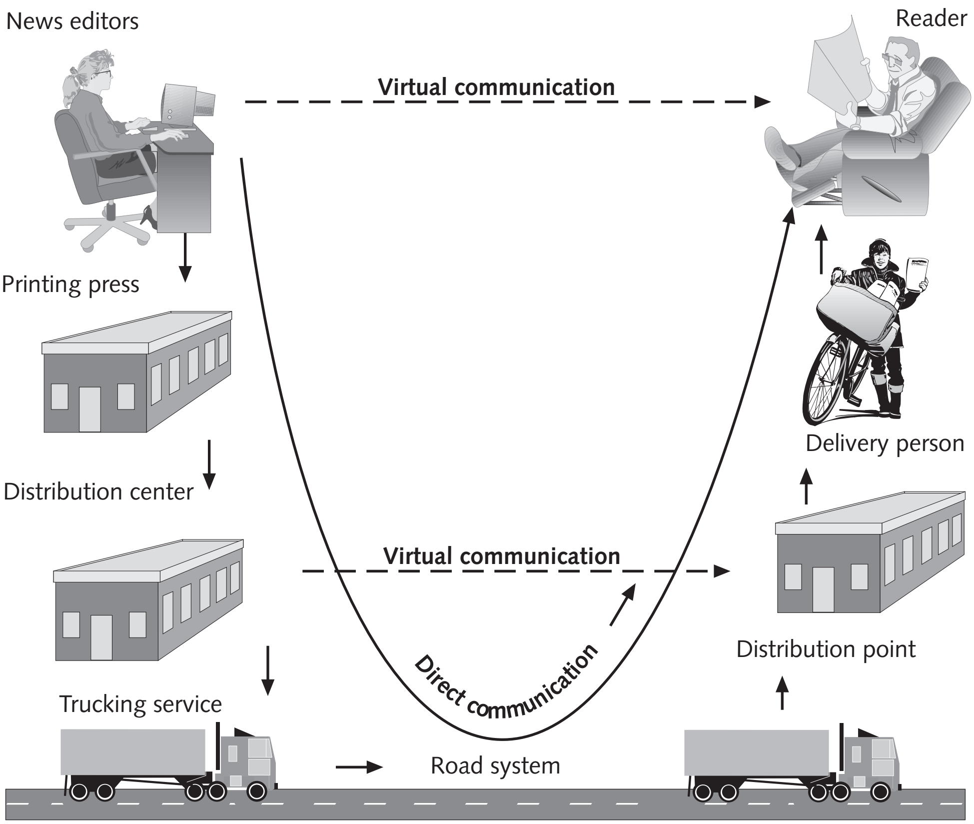

Figure 16-1 Virtual (logical) communication between editor and reader is possible because of direct communication between adjacent systems

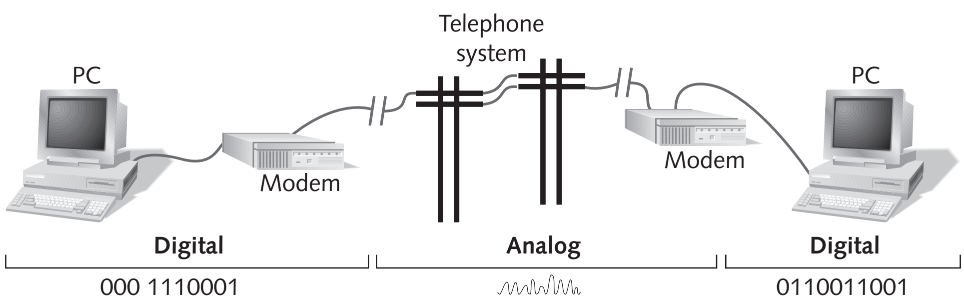

Figure 16-2 Communicating over phone lines can be viewed as direct or virtual

Even though communications over phone lines are customarily thought of as direct, this communication can also be considered virtual. Look at Figure 16-3, where two users are communicating by way of their PCs and modems. The communication between the two users is virtual and is possible because of the underlying supporting layers of adjacent systems, which are communicating directly.

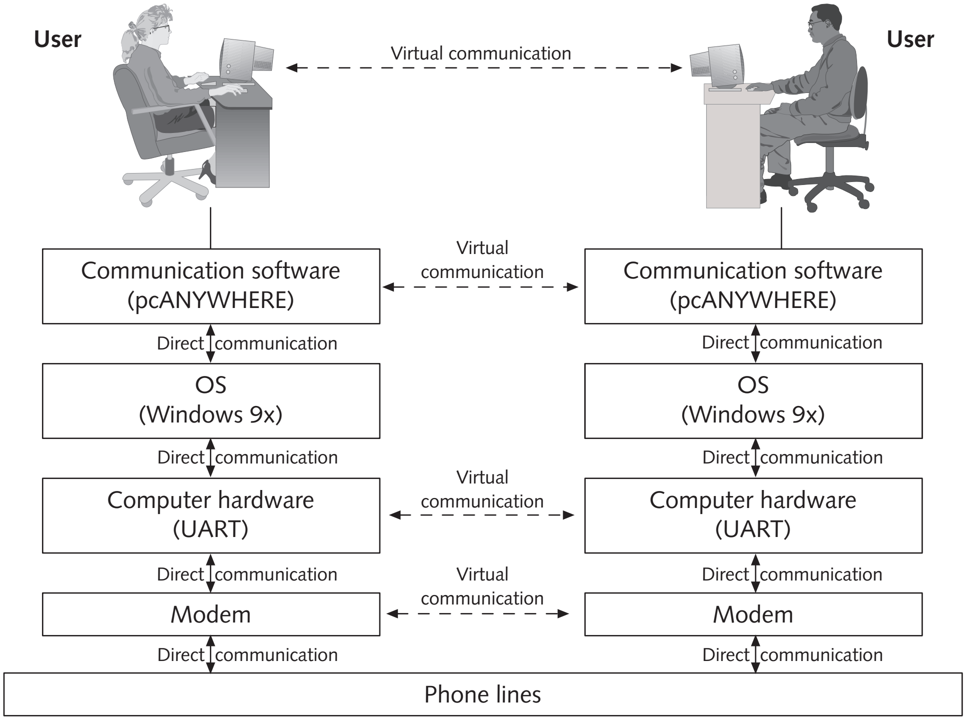

Figure 16-3 Communications over phone lines is both direct (between adjacent systems) and virtual (between similar systems)

One user enters data into his or her communications applications software, such as pcANYWHERE or ProComm Plus. The communications applications software communicates with the OS, which communicates with the computer hardware. The computer hardware communicates with a modem, which uses phone lines to send the information to a remote modem, with communication passing from computer hardware to the OS to communications software, and finally to a remote user.

In the newspaper analogy in Figure 16-1, virtual communication is taking place between reader and editor, but other underlying systems are also communicating with their counterpart systems at remote locations. For example, the distribution center receives an order for newspapers from a remote distribution point in the city, and the center fills the order, sending newspapers to the remote point. This, too, can be seen in the drawing as virtual communication.

Virtual communication at different levels of data communication also occurs. In Figure 16-3, the communications software on one end says to the communications software at the other end, "I want the such-and-such file." The remote software responds and sends the file. As you read this chapter, you see virtual communication taking place computer-hardware-to-computer-hardware, as well as modem-to-modem. This communication between correlating systems on corresponding layers of each side of the drawing is virtual, but communication from one layer to the next adjacent layer in the drawing is direct.

The remainder of this chapter examines each layer, or level of communication, shown in Figure 16-3, beginning with the modem layer and working up the diagram to computer hardware, OS, and finally communications software.

ALL ABOUT MODEMS

The **modem** is a device used by a PC to communicate over a phone line. A modem can be an external device (see Figure 16-4) or a modem card (see Figure 16-5). A modem card uses either an ISA or PCI slot.

Figure 16-4 SupraSonic external modem

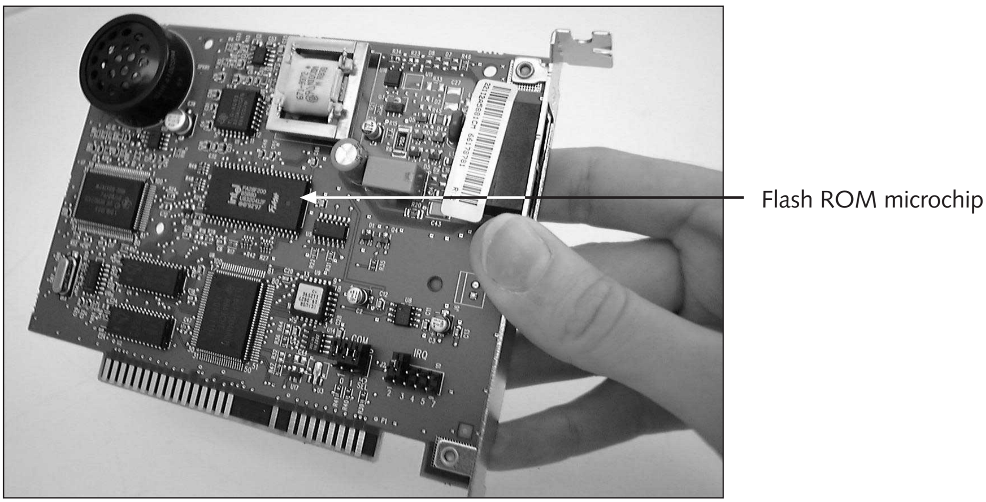

Figure 16-5 3Com U.S. Robotics 56K Winmodem modem card

To reduce the total cost of a computer system, some system boards have a small expansion slot, less than half the length of a PCI slot, called an **audio/modem riser (AMR)** (See Figure 16-6) slot or a **communication and networking riser (CNR)** slot. The small slot accommodates a small, inexpensive type of modem card called a **modem riser card**. In addition, the AMR slot can support an audio riser card, and the CNR slot can support an audio riser card or a networking riser card. A riser card has part of the audio, modem, or networking logic on the card and part on a controller on the system board.

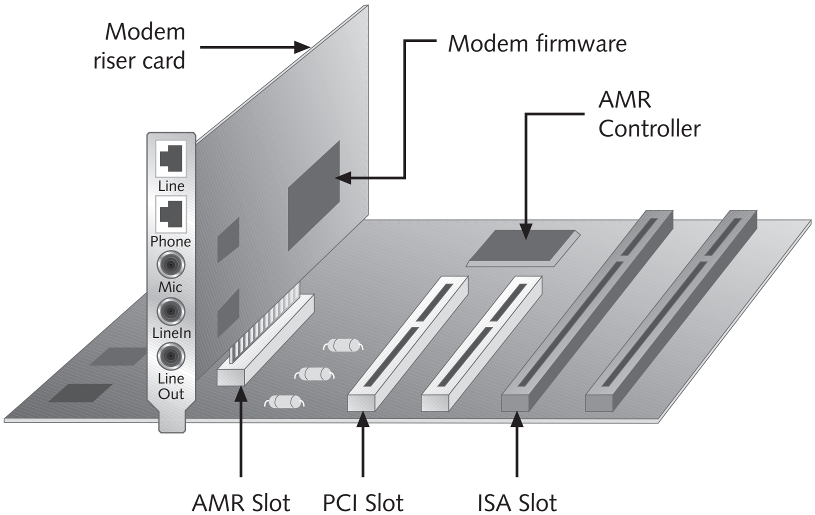

Figure 16-6 An audio/modem riser slot can accommodate an inexpensive modem riser card

A+ CORE 1.1

Regardless of the type of modem card or external device, a modem is both hardware and firmware. On the device is firmware on ROM chips that contains the protocol and instructions needed to format and convert data so that it can be transported over phone lines to a receiving modem on the other end. In general, modems are considered to be hardware, but it is fundamental to an understanding of communications to also consider them to be firmware.

Computers are digital; regular phone lines are analog. Earlier chapters discussed the difference between digital data and analog data, and Figure 16-2 shows how this concept applies to phone lines. Recall that data is stored inside a PC and communicated to a modem as binary or digital data—0s and 1s. A modem converts this binary, or digital, data into an analog signal (the process is called **modulation**) that can travel over a phone line, and then the modem at the receiving end converts it back to digital (this process is called **demodulation**) before passing it on to the receiving PC. The two processes of MOdulation/DEModulation lead to the name of the device: modem.

Recall that an analog signal is made up of an infinite number of possible values in its range of values, but a **digital signal** has only a finite number of values in its range of values. Remember also that phone lines were designed to transmit sound (that is, the human voice,

which is analog). Sound traveling over regular phone lines is transmitted as analog signals, meaning that there are an infinite number of sound values, just as there are an infinite number of sound values in the human voice. When data is transmitted over phone lines, even though the data from a PC is inherently digital, it, too, must be converted to an analog signal in order to use telephone technology. Think of PC data as being converted from two simple states or measurements (0 and 1, or off and on) to waves (like sound waves), which have a potentially infinite number of states or measurements. Modems use different characteristics of waves to correspond with the 0s and 1s of digital communication.

A+CORE 1.4

Two PCs communicate over phone lines by using either internal or external modems. Either way, the modem provides a connection for a regular phone line called an **RJ-11** connection, which is the same type of connection that you see for a regular phone wall outlet (Figure 16-7). In addition to a line-in connection from the wall outlet, a modem also has an extra RJ-11 connection for a telephone.

A+CORE 6.1

A modem must be able to both receive and transmit data. Communication in which there can be transmission in only one direction at a time is called **half-duplex**; an example of this type of communication is a CB radio. A modem that can only communicate in one direction at a time is called a half-duplex modem. Communication that allows transmission in both directions at the same time is called **full-duplex**; regular voice phone conversations are an example of full-duplex communication. If a modem can communicate in both directions at the same time, it is called a full-duplex modem.

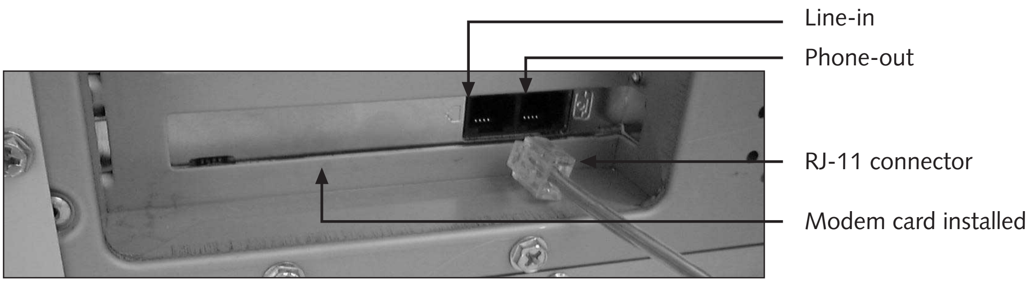

Figure 16-7 An RJ-11 connection on a modem is the same as that used for a regular phone connection

How Modems Are Rated

A PC initiates a phone call by instructing its modem to make the call. The modem makes the call, and a modem on the remote end answers the call and passes notification of this event on to its PC. The two PCs communicate with one another by using the modems as their interpreters, or translators. Because information traveling over phone lines is analog in nature and data processed by a PC must be digital, the two PCs can communicate only if the modems between them are translating data from digital to analog before sending it onto the phone lines, and then translating received data back to digital before the PC sees it.

A modem can translate digital data into an analog signal in many ways so that a receiving modem can understand it, quality of transmission can be assured, and the best possible transmission speeds can be attained. Using Windows 9x, you can view the properties of an installed modem on a PC. Many people install their modems by simply choosing settings supplied by others, or by allowing the installation program to use default selections. (They may not even understand what these modem properties mean or why certain selections, such as transmission speed and method of controlling data flow, are made.) This section explains what each modem property means and how it affects the modem's performance and compatibility with other modems in order to make communication possible.

Getting Started

When you first use a modem to make a dial-up call to another PC, you hear the modem making noises as the dial-up is completed. The two modems are establishing the rules of communication between them. What you hear are the sounds being sent over the phone lines as the two modems negotiate these rules. The process is called **training** or **handshaking**. Modems use one of many protocols (agreed-on methods of communication) to communicate, and, in this handshaking phase, the calling modem and the receiving modem are communicating the protocols and speeds they can support, and arriving at the best possible common solution. The decisions made about protocols include how to handle data compression and error checking, and what methods of data transfer will be used.

Modem Speeds

A+ CORE 1.1

The speed at which a modem passes data over phone lines is partly determined by the transmission standard the modem is using. Modem speed is measured either in **baud rate** (named after the inventor, J. M. E. Baudot), which is the number of times a signal changes in one second, or in **bits per second (bps)**; bps is the more common unit of measurement. For slower baud rates, one signal represents one bit (in which case baud rate is equal to bps rate); slower modems are often measured in baud rates. For faster baud rates, one signal can represent more than one bit, so faster modems are measured in bps (and baud rates may differ from bps rates). When measuring modem speed using baud rate, the number of bps will always be equal to or a multiple of the baud rate. The most commonly rated speeds of modems in use today are 14.4 Kbps, 28.8 Kbps, 33.6 Kbps, and 56.6 Kbps.

The maximum speed of a modem is often written into the manufacturer's name for the modem. To see what your modem rating is when using Windows 9x, click **Start**, point to **Settings**, click **Control Panel**, and double-click **Modems**. You see the Modems Properties dialog box in Figure 16-8. The installed modem is labeled as a 3334 33.6 FDSP Fax Modem. The 33.6 portion of the name indicates the maximum speed of the modem: 33.6 Kbps.

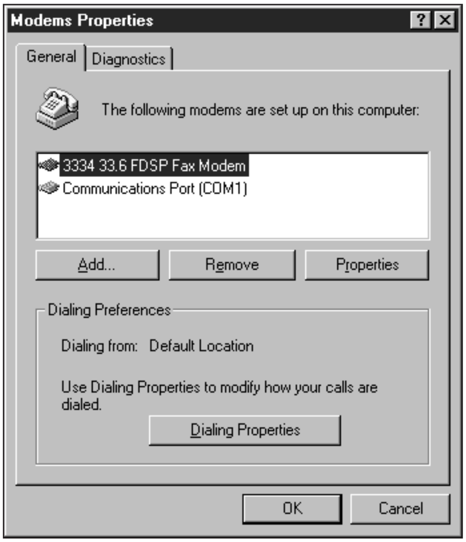

Figure 16-8 The maximum modem speed is often included in the modem name (in this case 33.6 Kbps)

The Ceiling on Modem Speeds

Many factors contribute to limitations on modem speeds. One of these limitations is caused not by the limits of modem technology, but rather by the nature of regular phone lines and what they are designed to do. Analog phone lines were designed to provide only sufficient audio signal quality to support the transmission of the human voice. This limited quality of audio signals affects our ability to attain high transmission speeds for data. In addition to the limitations on analog lines, newer digital phone lines have limitations as well. Older phone lines (before 1940) were analog from beginning to end, with no digital components. This is not true today; regular (analog) telephone lines are always analog as they leave a house or office building. However, the analog signals are almost always converted to a digital signal at some point in the transmission. These digital signals are then transmitted, using sophisticated computing equipment and methods, and converted back to analog signals at some point before traveling the last step between a local central telephone company office and the phone of the person receiving the call.

16

One limitation on modem speeds using regular phone lines results from the method used when an analog signal is converted to a digital signal somewhere along the phone line route. This is how it's done: the phone company takes a sampling of the analog signal (8,000 samples every second) and converts each sample to an 8-bit byte. So, modem transmission is limited to this 8,000 bytes/second (64,000 bits/second) transmission of the digital signal.

TIP

Because of the sampling rate used by phone companies when converting an analog signal to digital, taking into account the overhead of data transmission (bits and bytes sent with the data that are used to control and define transmissions), the maximum transmission rate that a modem can attain over a regular phone line is about 56,000 bps or 56 Kbps.

Other factors further limit modem speed. For a modem to achieve this high a transmission rate, the conversion by the phone company from analog to digital can only take place once during the transmission. Also, if the lines in your neighborhood are multiplexed (several logical phone lines sharing a common physical line), the 56K speed cannot be attained. The line also often has some disturbance, called **noise**, which can be caused by lines bumping against one another in the wind, fluorescent lighting, nearby radios or TVs, bad wiring, lightning, and so forth. This reduction in line quality is called a dirty or noisy line. A line that consistently produces high-quality results is called a clean line.

Modem Standards

The telecommunications industry sets several modem standards to determine modem speed and protocols. The industry-approved standards for international communication were written by **Comité Consultatif Internationale de Télégraphique et Téléphonique (CCITT)**. In 1992, the CCITT organization was incorporated into the **International Telecommunications Union (ITU)**, an intergovernmental organization approved by the United Nations to be responsible for adopting standards governing telecommunications. You might see the standards used by modems referred to as the CCITT standards (more common) or as the ITU standards. The CCITT standards are listed in Table 16-1.

TIP

Avoid purchasing a modem using a proprietary standard because it may only be able to communicate with another modem by the same manufacturer.

Table 16-1 Transmission standards used by modems

Standard	Applies Mainly to	Description
Bell 212A	Speed (up to 1,200 bps)	An older standard that supports 1,200 bps
CCITT V.32	Speed (up to 9,600 bps)	This standard runs at 9,600 bps, includes error checking, and can negotiate standards with other modems. V.32 uses 2,400 baud, transmits 4 bits per each baud, or 9,600 bps. This standard was used for quite some time.
HST	Speed (up to 14.4 Kbps)	An older proprietary standard that supports 9,600 or 14,400 bps, created by U.S. Robotics. (U.S. Robotics also supports the CCITT standards.)
CCITT V.32bis	Speed (up to 14.4 Kbps)	This standard is an improvement over V.32 (bis means "second" in Latin), and has a speed of 14,400 bps. It transmits at a 2,400 baud rate and transmits 6 bits per baud, or 14,400 bps.
CCITT V.34	Speed (up to 33.6 Kbps)	This standard transmits at 28,800 bps, or 28.8 Kbps. Optional higher speeds are 31.2 Kbps and 33.6 Kbps. This standard prevails today.

Table 16-1 Transmission standards used by modems (continued)

Standard	Applies Mainly to	Description
MNP Class 4	Error correction	Developed by Microcom, Inc. and called the Microcom Networking Protocol (MNP), this standard provides error detection and correction, and also automatically adjusts the speed of transmission based on the quality of the phone line. Earlier classes of MNP standards for error correction are Class 2 and Class 3.
CCITT V.42	Error correction	This is an error-correcting standard that adopted the methods used by MNP Class 4. Data that is corrupted during transmission is automatically retransmitted using this standard. A modem can use this standard for error correction and one of the standards listed above for speed.
MNP Class 5	Data compression	MNP Class 5 standard provides data compression, which can double normal transmission speeds between modems. It is common to see both MNP Class 4 and MNP Class 5 supported by a modem. They are sometimes called MNP-4 and MNP-5.
CCITT V.42bis	Data compression	An improved version of V.42 that also uses data compression. Many modems use the V.42bis standard for data compression and error checking and, at the same time, use the V.34 standard for data transmission protocols.
K56flex	Speed (up to 56 Kbps)	One of two earlier standards used to attain a speed of 56 Kbps. This standard was backed by Lucent Technologies and Rockwell International Corp.
x2	Speed (up to 56 Kbps)	One of two earlier standards that support a speed of 56 Kbps. This standard was supported by U.S. Robotics.
V.90	Speed (up to 56 Kbps)	The current standard used to attain speeds of 56 Kbps. It replaces both K56flex and x2.

A+ CORE 1.1

16

When one modem dials another modem, during the handshake they attempt to establish a communications protocol or standard at the fastest speed that both can support. The receiving modem takes the lead in negotiating these protocols by offering its best solution. If the calling modem does not respond to this protocol, the receiving modem continues to offer a slower protocol until they agree on the fastest possible solution common to both. Data-compression and error-checking protocols are also negotiated and agreed upon during the handshake, if both modems can support the same standards for these features. More details about handshaking are covered later in the chapter.

Here's one example of the many standards that might be supported by a single modem. Listed in Figure 16-9 are the standards supported by the 3Com U.S. Robotics 56K

Winmodem shown in Figure 16-5. Note in Figure 16-9 the many different modulation schemes (which indicate speed) that the modem can support. The fastest standard, ITU-T V.90, is the standard that the modem first uses when trying to establish communication with another modem, unless specified otherwise in the modem setup. Note on the right side of Figure 16-9 the different speeds that can be supported under each standard and in the lower-left corner of the figure the different error-control and data-compression standards supported. The more standards a modem supports, the more likely it will be able to establish good communication with any other modem.

Modulation Schemes

ITU-T V.90
3Com 56K technology
ITU-T V.34+
ITU-T V.34
ITU-T V.32bis
ITU-T V.32
ITU-T V.23
ITU-T V.22bis
ITU-T V.22
Bell 212A
ITU-T V.21
Bell 103

Error Control and Data Compression Schemes

ITU-T V.42
ITU-T V.42bis
MNP 2-5

Fax Modulation Schemes

ITU-T V.17
ITU-T V.29
ITU-T V.27ter
ITU-T V.21

Fax Standards

EIA 578 Class 1 FAX
EIA 592 Class 2.0 FAX

Front Channel Link Rates

28000, 29333, 30666, 32000, 33333, 34666, 36000, 37333, 38666, 40000, 41333, 42666, 44000, 45333, 46666, 48000, 49333, 50666, 52000, 53333, 54666, 56000, 57333

Back Channel Link Rates

4800, 7200, 9600, 12000, 14400, 16800, 19200, 21600, 24000, 26400, 28800, 31200

V.34+ Link Rates

4800, 7200, 9600, 12000, 14400, 16800, 19200, 21600, 24000, 26400, 28800, 31200, 33600

V.32bis Link Rates

4800, 7200, 9600, 12000, 14400

Additional Link Rates

300, 1200/75 (V.23), 1200, 2400

Fax Link Rates

2400, 4800, 7200, 9600, 12000, 14400

Figure 16-9 Specifications for a 56K modem

You can force a modem to use a particular standard that it supports. For example, if you want to force this modem to communicate with another modem using the Bell proprietary standard, in Windows 9x, follow these steps:

1. Click **Start**, point to **Settings**, click **Control Panel**, and then double-click **Modems**. The Modems Properties dialog box opens.
2. Select the modem from the list of installed modems, and then click **Properties**. You see the Properties dialog box for the selected modem, as shown in Figure 16-10. Note in this figure that the maximum speed of the modem is set to 115,200 bps; this speed is not attainable over phone lines. You can, however, use this dialog box to offset problems with a dirty phone line by forcing the modem to transmit at a slower

speed than it normally would. Slowing down the speed of your modem might solve the problem.

3. Click the **Connection** tab of the modem Properties dialog box. Figure 16-11 shows the connection preferences supported by this modem. These preferences are discussed later in the chapter.

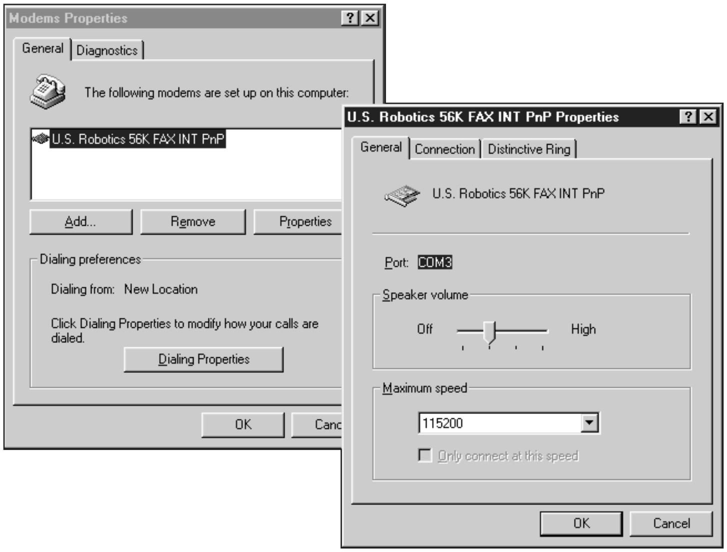

Figure 16-10 The Properties box of the selected modem

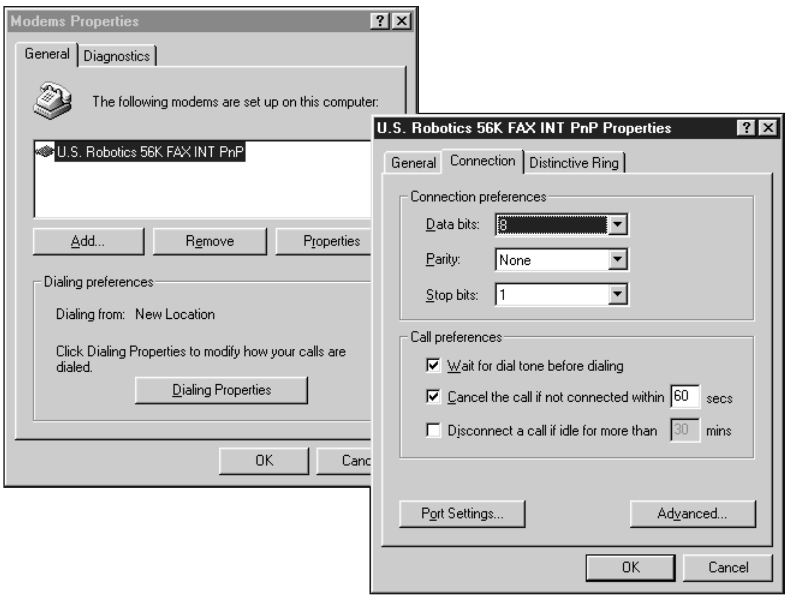

Figure 16-11 Connection preferences supported by the installed modem

16

4. Click the **Advanced** button. Figure 16-12 shows the advanced connection settings, which let you select a modulation standard for this modem. The figure shows the drop-down list of standards. You can select Non-standard or Standard. The standard selection for this modem causes the modem to function according to one of the CCITT modulation standards listed in Figure 16-8. If you select the Non-standard setting, this modem attempts to communicate using the Bell212/103 standard listed in Figure 16-9 under "Modulation schemes."
5. Leave the Modulation type set to Standard and click **Cancel** to exit the dialog box.

Modems with 56 Kbps Speeds

A+CORE 1.1

Before 1998, there were two standards for 56-Kbps transmission, the x2 standard supported by U.S. Robotics and the K56flex standard supported by Lucent Technologies and Rockwell International Corp. These two standards were not compatible with one another. Because of this incompatibility, all three companies agreed to support a third standard for 56 Kbps transmission. This standard, called the **V.90** standard for 56 Kbps, was published by ITU in February 1998. If you have a modem that uses either the x2 or the K56flex standard, it is likely that you can upgrade the Flash ROM on the modem card to use the new standard. See the Web site of the modem manufacturer for more information.

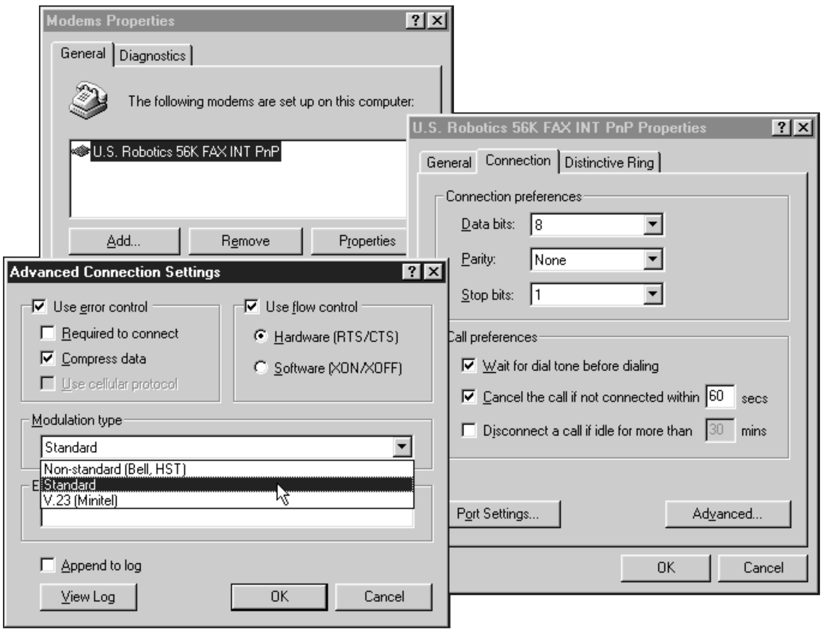

Figure 16-12 Advanced Connection Settings allows you to select a transmission standard for the installed modem

Another concern about buying a 56-Kbps modem is that, if your phone line is too noisy, the modem cannot attain the high speed. 3Com, a modem manufacturer, offers a way for you to test your phone line to determine if it qualifies, before you buy a 56-Kbps modem. With

a modem using the V.34 standard, access the 3Com Web site (*www.3com.com/56k/need4_56k/linetest.html*) and read and follow the directions to have the 3Com program analyze your line.

Although modems are rated and advertised to transmit at 56 Kbps, this speed is seldom accomplished. When one PC is communicating with another, even if both PCs are equipped with 56K modems and using clean phones lines, most likely the actual attained speed will not exceed 34 Kbps. When a PC is connected to an Internet service provider (ISP), to come close to the 56-Kbps transmission, the ISP's incoming lines must be digital rather than analog. Even so, the transmission from the provider to the PC (called downstream transmission) is only about 53 Kbps, and the transmission from the PC to the provider (called upstream transmission) does not exceed 34 Kbps.

TIP

Before upgrading to a 56-Kbps modem, check with your ISP and find out if they support this speed.

Data Compression

Recall the concept of communications layers presented earlier in the chapter. The next discussion focuses on the direct communication between the two adjacent layers represented by the modem and the phone lines. The modem includes the firmware (permanent programming) housed on the modem, which can perform error correction and data compression. These and other functions of data communication can be performed by either hardware (firmware on the modem) or software (programs on the PC).

When data compression is performed by a modem, it applies to all data that is transmitted by the modem. If data compression is performed by the software on the PC, it applies to single-file transfer operations. Software protocols used to compress data will be addressed later in the chapter.

Data compression done by the modem follows either the MNP-5, CCITT V.42, or V.42bis protocol. All three of these protocols also perform error correction. A modem using one of these methods of data compression is communicating to its computer at higher speeds than it is communicating to the phone line. This is because the data is being compressed at the modem and, therefore, there are more bits coming from the local computer into the modem than are being transmitted over the phone line (assuming, of course, that few errors occur). This fact may cause the overall speed of the data transmission at the PC to appear much faster than the actual phone line transmission rate.

The compression ratio of MNP-5 is 2:1, and V.42bis can have up to a 4:1 compression ratio. MNP-5 also has more overhead in its compression methods, and sometimes, if a file is already compressed (such as a ZIP file), because of this overhead, the actual transmission time increases because MNP-5. V.42 can determine if a file is already compressed, and therefore does not compress it a second time.

> TIP
> If you are sending files that are already compressed over a modem, and the only compression standard your modem supports is MNP-5 compression, disable MNP-5 compression to speed up data transmission.

Error Correction

As seen in Table 16-1, the standards that include error correction are MNP-4, CCITT V.42, and CCITT V.42bis. One modem often supports all three standards. If it doesn't, during the handshaking process, the answering modem tries to establish an error-correction protocol with the other modem by first suggesting the fastest, best standard. If the calling modem responds by accepting that standard, then it is used by both. If the calling modem does not support the suggested protocol, then the two modems negotiate to find the best protocol they both can use, or simply decide not to use error correction.

Look back at Figure 16-12: the Advanced Connection Settings for the installed modem. From this dialog box, you can click **Use error control** to determine if the modem can use error control, if it can negotiate a protocol with the other modem. You can also specify from this dialog box that error control is required to connect. (Click **Required to connect** under **User error control** in the dialog box in Figure 16-12.) If the other modem cannot use error control, then this modem does not complete the connection. Also note that data compression cannot be selected unless error control is evoked.

Error correction works by breaking data up into small packets called **frames**. The sending modem performs some calculations on a frame of data and sums these calculations into a checksum. A **checksum** is a summary calculation of data and will later be used to check or verify the accuracy of the data when received. Checksum works somewhat like a parity bit, except that it is a little more complicated and applies to more data. The checksum is attached to the data frame, and they are transmitted together. The receiving modem performs the same calculations and compares its answer to the checksum value received. If they do not agree, then the receiving modem requests a new transmission of the packet. This process does slow down the transmission of data, especially on dirty or noisy phone lines, but accuracy is almost 100% guaranteed.

More About Handshaking

Now that you understand several of the different protocols that must be established between two modems before they can communicate data, you can more carefully examine the handshaking process in which these protocols are agreed upon. Follow the step-by-step process of two modems performing a handshake:

1. The calling modem dials a phone number, and the phone rings at the other end.
2. The answering modem picks up. The answering modem sends a modem tone, sometimes called a **guard tone**, which the calling modem recognizes as another modem and not a human voice, and so it does not break the connection.
3. The answering modem sends a signal called the **carrier**. This is an unmodulated (unchanging) or continuous tone at a set frequency (also called pitch), which

depends on the speed of communication the answering modem is attempting to establish with the calling modem. This process, called establishing carrier, sounds like static, which you hear during handshaking.

4. The answering modem keeps sending one unmodulated carrier (or signal) after another until the calling modem responds.
5. If the calling modem responds with the same carrier, both modems use it. If the calling modem does not respond, the answering modem simply drops this particular carrier and tries another.
6. After carrier is established, the two modems enter the equalization stage, which sounds like hissing or buzzing on the line. The modems are both testing the line quality and compensate for poor quality by changing the way they transmit.
7. Having established carrier and adjusted for line quality, the two modems have now agreed on a speed of data transmission between them, called the **modem speed** or the **line speed**.
8. The speakers on the modems are now turned off. Next the modems begin to talk about how they will transmit data. The answering modem asks if the other modem can support MNP-4, MNP-5, V.42, V.42bis, and so on. After some interchange, the methods of data transmission are agreed upon, and the handshaking is complete. The two modems can now communicate.

External modems give you the status of what is happening by turning on and off lights on the front of the modem and displaying messages on an LCD panel (called a display readout). Internal modems, of course, don't have these lights available for you to see, so communications software sometimes displays a pseudo-modem-panel on your computer screen. The modem lights were listed in Table 9-3 of Chapter 9 and are discussed in more detail later in this chapter.

When a modem is first activated (turned on), it initializes itself and then raises (turns on) its Clear to Send (CTS) signal and, for an external modem, the CTS light also goes on. When the PC receives the CTS signal from its modem, it will raise its Request to Send (RTS) signal in order to begin a call. For external modems, the RTS or RS light goes on.

16

TIP

Communications technicians use the terms "raising" and "dropping" signals to mean that the signal is either started or stopped, respectively.

After the handshaking explained in Step 7 above, when carrier between the two modems is established, if the modems are external modems with status lights, each modem turns on its Carrier Detect (CD) light, which stays on as long as the modems are connected. When a communications technician sees this light, he or she will say that carrier is up. Not only does the light come on, but the CD signal transmitted to the PC over the serial port cable is also raised, letting the computer know that communication has been established, and that data can now be sent. Data transmission can be detected by looking at the external modem lights, TXD and RXD (or they may be TD and RD) for transmitting and receiving data.

If error correction or data compression is used, the communication established will most likely be synchronous over the phone line, which means that data is sent from one modem to the other as blocks of data based on timed intervals. Clocks on each modem are used to synchronize the transmissions. Asynchronous communication relies on bits being sent before and after the data to communicate when each modem should transmit. These bits are called **stop bits** and **start bits**. Asynchronous communication can also use parity checking.

Modem Features

In addition to the speed, protocols, data compression, and error correction that are used to rate a modem, there are other features. Some additional abilities you might want to look for in a modem are:

- **Caller ID** (provided that you subscribe to that service from the phone company) is supported.
- **Display readout** on external modems provides information about the status of the modem. (See Chapter 9, Table 9-3, for a list of modem lights and their meanings. The modem can also have an LCD panel for messages such as Training or Idle.)
- **Flash ROM** allows you to upgrade your modem to support future standards.
- **Plug and Play for Windows 9x** makes modem installation more automatic.
- **Voice/data capability** allows the modem to also serve as a telephone, complete with built-in speaker and microphone.
- **Auto-answer** makes it possible for the modem to receive incoming calls while you are away from the PC.

Computer-Hardware-to-Modem Communication

Looking back to the newspaper analogy (see Figure 16-2), the newspaper distribution system must coordinate its efforts with the trucking system. In data communication with computers, this coordination can be equated to the computer hardware coordinating its communication with its modem. Between the PC hardware layer and the modem layer, communication is digital. How the PC hardware and the modem communicate is the subject of this section.

A+ CORE 1.1

Figure 16-13 shows an overview of the way that PCs and modems communicate. The computers are classified as **data terminal equipment (DTE)**, and the modems are called **data communications equipment (DCE)**.

PCs don't communicate with modems in the same way that modems communicate with other modems. Transmission speeds, error checking, and data format from the PC to the modem (DTE to DCE) are different than they are between a modem and another modem (DCE to DCE). Remember that a modem may be an internal or an external modem. As you study communication between DTEs and DCEs, the concepts are easier to visualize if

you think of a PC and an external modem sitting beside it connected by a serial cable. However, the same concepts apply to an internal modem as to an external modem, even though the modem card and the PC are not connected by a cable.

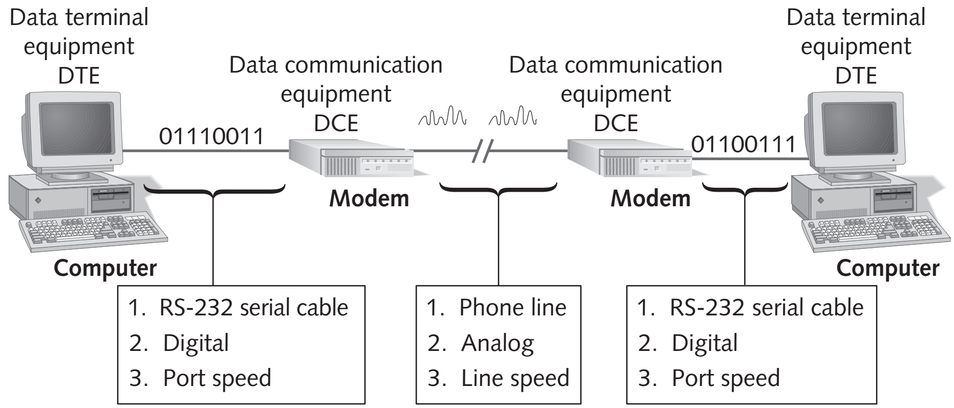

Figure 16-13 A computer communicates with a modem differently from the way a modem communicates with another modem

Transmission Speed

Data transmission involves three speeds (see Figure 16-13): the speed between the calling PC and its modem (called the **port speed**), the speed between the two modems (called the modem speed or the line speed), and the port speed between the answering PC and its modem. The overall speed of data transmission is affected by each of these speeds.

Look back at the modem properties for a 56K modem in Figure 16-10. Notice that the maximum speed that is available for this modem is 115200. This speed is given in bps, and you naturally may wonder why it is so much higher than the rated speed of the modem. The answer is that this speed is referring to the transmission speed from the PC to the modem (the port speed), which may very well be this high.

Now turn back to Figures 16-10 and 16-13. The speed labeled "Maximum speed" in Figure 16-10 refers to communication between a DTE (computer) and a DCE (modem) and is called the DTE speed, or the port speed, because the PC is using a serial port to communicate with the modem. The port speed must be significantly higher than the modem speed in order for the PC to take advantage of data compression performed by the modem.

TIP As a general rule, port speed should be at least four times as fast as modem speed.

For example, for a 28.8 Kbps modem, set the port speed to 115.2 Kbps. The speed seen in Figure 16-10 is the port speed that is supported by this particular modem. Modem speed (line speed) is determined by several factors, including the rated speed of the modem, the line quality, and the speed of the remote modem.

The UART

Recall from Chapter 9 that the chip responsible for any communication over a serial port is the UART (universal asynchronous receiver-transmitter), sometimes called an ACIA (asynchronous communications interface adapter). The UART controls the port speed as well as other features of serial port communications. Table 16-2 summarizes the speeds and different models of the UARTs.

Table 16-2 Maximum port speeds of UARTs

UART	Maximum Speed	FIFO Buffering	Comments
8250, an 8-bit chip	38.4 Kbps	None	Improvements to this chip are the 8250A and 8250B.
16450, a 16-bit chip	38.4 Kbps	None	This chip fixed bugs in the 8250 chip and improved performance.
16550, a 16-bit chip	115.2 Kbps	Has a 16-byte buffer	The 16550A version of this chip fixed a bug in the 16550. 16550AF chip improves on the 16550A chip.
16650, a 16-bit chip	230 Kbps and higher	Has a 32-byte buffer	Performance is improving as new technologies arise.
16750	Up to 1 Mbaud	Has a 64-byte buffer	Produced by Texas Instruments

Remember from Chapter 9 that the FIFO (first-in-first-out) buffer is needed by the UART chip to temporarily hold data as it is being received or transmitted. If your UART chip has a buffer, you can control its size as well as the port speed from the Modems Properties box of Windows 9x. Follow these directions:

1. Click **Start**, point to **Settings**, click **Control Panel**, and then double-click the **System** icon. Select the **Device Manager** tab.
2. Click the **+** sign beside **Ports (COM & LPT)** to display a list of ports.
3. Select the COM port used by your modem and then click **Properties**. Figure 16-14 shows the COM1 Properties dialog box. From here, you can select the port speed in bits per second.

4. Click the **Advanced** button to open the Advanced Port Settings dialog box, as in Figure 16-15. From here, you can control the size of the FIFO buffer of the 16550 UART and establish whether to use the buffer.
5. Click **OK** to close the dialog box.

Other settings on the Communications Port Properties box are discussed later in the chapter.

As you can see in Table 16-2, if you have a very fast external modem with data compression, but your UART cannot support the same speed, the modem cannot attain its maximum speed. The solution may be to upgrade your UART or to install an I/O controller card with a fast UART chip. Remember from Chapter 9 that you can use MSD (Microsoft Diagnostics) utility to determine which UART you have on your PC. When reading documentation about the speed of communication over phone lines, you may see the UART or port speed referred to as the DTE speed, and the modem or line speed called the DCE speed.

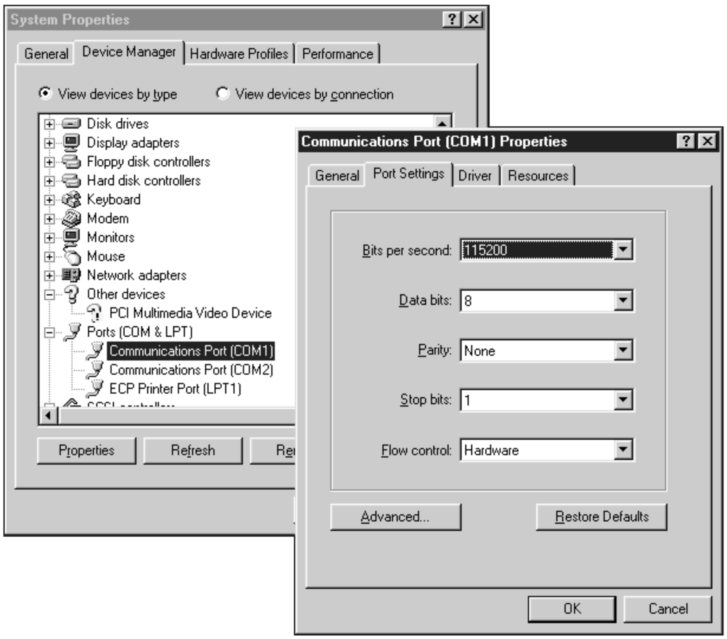

Figure 16-14 The COM1 Properties box lets you control port settings, including the port speed in bits per second

16

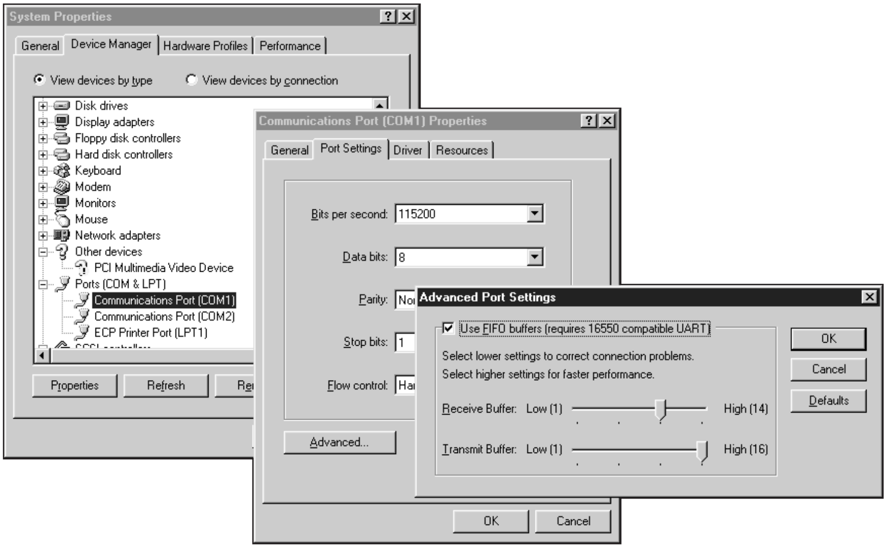

Figure 16-15 Selecting the FIFO buffer size of a 16550 UART chip

The UART Chip on External and Internal Modems

Let's now consider the different ways internal and external modems use the UART. Figure 16-16 shows the differences between an external and internal configuration of the UART. Almost all system boards sold today contain either a UART or the UART logic somewhere within the chip set on the system board. External modems connect to a PC by way of a serial port, and therefore use the UART on the system board that controls this serial port. In this case, data from the system board travels over the serial cable to the modem in digital form, so the external modem must have a UART in it to receive the digital data. Sometimes the external modem may combine the UART logic into other chips in the modem.

A+ CORE 1.3

Internal modems are expansion cards that connect to the system board by way of an ISA or a PCI expansion slot. Internal modems have their own UART on the modem card and provide their own serial port logic to the computer system. This is why an internal modem must be configured to have its own COM port assigned to it for its UART to control. A typical configuration for a PC is to have COM1 assigned to the serial mouse and COM2 assigned to the internal modem. (An external modem does not need a COM port assigned to it, because it uses the existing COM port already configured on the system.) The UART on the system board holding the internal modem is not used by the modem, because the modem is not using the COM ports on the system board.

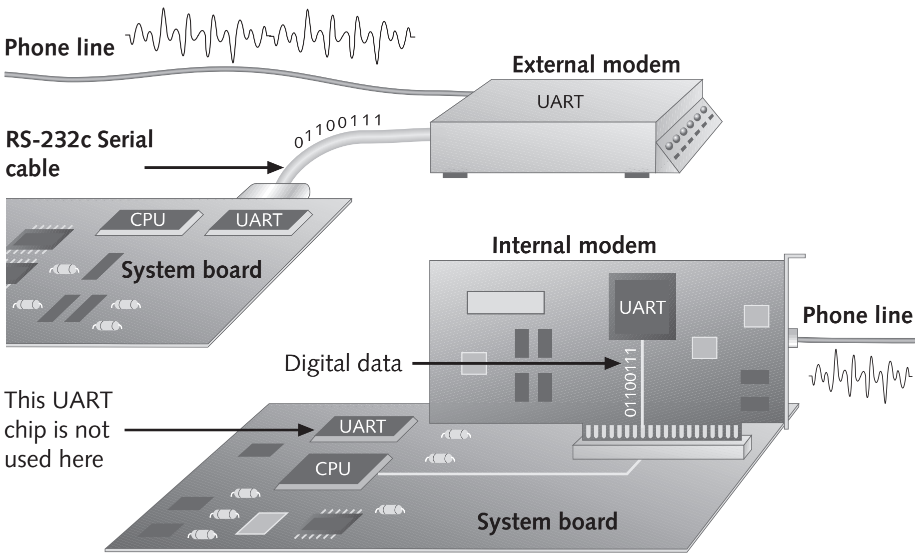

Figure 16-16 For an external modem, digital data is controlled by the UART chip on the system board; for an internal modem, the controlling UART chip is on the modem card

> **TIP** Sometimes a COM port on a system board can compete for resources with the COM port on an internal modem, causing a conflict. In this case, use CMOS setup to disable the conflicting COM port on the system board.

The UART on an internal modem and the UART chip on a system board supporting an external modem basically perform the same function—controlling digital data sent from the CPU to the modem. Either of these UARTs may perform error checking and control the flow of data. In the discussions that follow about the functions of the UART chip in modem communication, the same principles apply to either an external or an internal modem. The difference is the location of the UART performing the function.

In speaking of the need to upgrade a slow UART, a slow UART chip on an internal modem has the same effect as a slow UART chip on a system board supporting an external modem. A UART chip on an internal modem is also controlling the speed at which data is transferred from the system bus to the modem. If this UART is not fast enough, then your only recourse is to replace the modem card.

Flow Control

Recall that three speeds affect the overall speed of data transmission, line speed and the port speeds of the sending and receiving computers. Because each speed can differ, a way is needed to stop the data from flowing when either the DTE or DCE needs to catch up. For example, if the receiving modem is receiving data faster than it can uncompress it and pass it off to its PC, it must stop the flow coming from the remote modem long enough to catch up. **Flow**

control is a method of controlling the flow of data by sending a message to stop data flow. Either the receiving PC or the receiving modem can initiate a flow control message.

There are two methods of flow control: flow control over software channels, called Xon/Xoff protocol, and flow control over hardware channels, called RTS/CTS protocol. Looking back at Figure 16-12, you can see the two choices for flow control under Advanced Connection Settings. Figure 16-17 illustrates the difference between the two methods: Software flow control uses the same methods to send stop and start messages as it does to send data. Hardware flow control uses the same methods used by the modem (hardware) to initially establish communication.

In software flow control, the receiving device transmits a message to the sending device to pause transmission by sending a special control character within the same channel (frequency) in which data is sent. This method is called **in-band signaling**. The control character to stop the data from flowing, Xoff, is Control-S, sent as an ASCII character whose ASCII value is 19. (See Appendix C for information about ASCII characters.) The Xon control character is Control-Q, or ASCII value 17, which tells the sending device to begin sending data again. This method of flow control works well as long as only ASCII data is being transmitted, but if data is being transmitted in some other coding format, the control characters themselves may be valid data and may be mistakenly included in the data stream as regular data, which will cause problems with communication. Another problem with software flow control is that data needs to be continually monitored to detect the signals, and, at the high speeds at which data is transmitted today, the control character may not be detected in time to stop the data.

Instead of embedding signals within data, hardware flow control uses electrical signals from a PC to its modem that are not part of the data flow channel; this is called **out-of-band signaling**. Hardware flow control is a way for a PC to tell its modem to stop the other modem from sending data. When the first (receiving) modem receives the signal from its PC, it just deactivates the line between the two modems (how it does that is addressed below), forcing the other modem to wait. In order to understand how hardware flow control works, turn your attention back to a subject from an earlier chapter: serial port communication.

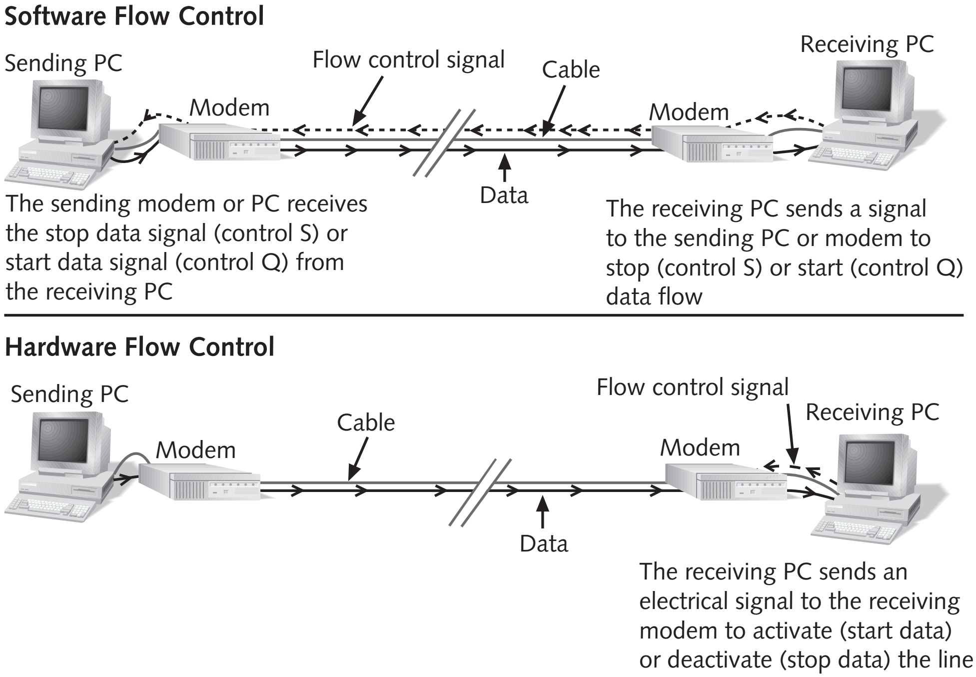

Figure 16-17 Software flow control sends in-band software messages from the receiving PC to the sending device; hardware flow control sends out-of-band electrical signals only from the receiving PC to the receiving modem

RS-232c Serial Port Communication

Remember from Chapter 9 that serial port communication on PCs follows the RS-232c standard, which specifies how information and commands travel over nine wires in the serial cable. All RS-232c serial communication is controlled by the UART chip. Hardware flow control is accomplished by the UART chip, using two of these wires: one to stop and one to start the data.

As you can see from Figure 16-17, with hardware flow control the signal to stop or start data flow need only travel from the receiving PC to the receiving modem. Remember that the cable uses nine wires and can have either a DB25 (25-pin) or a DB9 (9-pin) connection at either end. Table 16-3 lists the purpose of each of these nine wires and the pin connection for both the DB9 and DB25 connectors at the computer or DTE end. On a PC, serial port communication is asynchronous, meaning that data flow does not stay in sync with a clock. The RS-232c standard includes pin outs used to synchronize data transmission with the receive and transmit clocks, but, since PCs don't use this feature, only nine pins are used, making possible the more convenient 9-pin connection for PCs rather than always requiring a 25-pin port.

Table 16-3 RS-232c standard for serial port cable pins

Pin Number for 9-Pin Connector	Pin Number for 25-Pin Connector	Pin Use	Description	Modem Lights
1	8	Carrier detect	Connection with remote is made	CD or DCD
2	3	Receive data	Receiving data	RD-RXD
3	2	Transmit data	Sending data	SD or TXD
4	20	Data terminal ready	Computer is ready to control modem	TR or DTR
5	7	Signal ground	Not used with PCs	
6	6	Data set ready	Modem is able to talk	MR or DSR
7	4	Request to send	Computer wants to talk	RTS
8	5	Clear to send	Modem is ready to talk	CTS
9	22	Ring indicator	Someone is calling	AA or RI

Looking back at flow control settings in Figure 16-12, you can see which of the two pins in Table 16-3 is used for hardware flow control: RTS and CTS. RTS is used by the computer, and CTS is used by the modem. In most cases, RTS and CTS stay on the entire time a communication session is active. Also, remember that between the two modems, carrier (indicating that the line is still open) from each modem must also stay up for communication to take place. When the receiving computer wants to stop receiving data, it drops the RTS signal. Its modem responds by dropping the CTS signal and refusing to acknowledge the receipt of data from the sending modem, thus stopping communication. When the receiving computer is ready for more data, it raises RTS, and the receiving modem responds by raising CTS and, once again, acknowledges received data. Communication resumes.

Additional UART Protocols

When a UART chip from a sending device sends digital data to a sending modem, it first prepares the data to be received by the UART chip on the other end. When the UART chip on the receiving end of the transmission receives digital data from its modem, it performs some error checking based on information sent to it from the sending UART chip. Think of this process as another communication layer: UART-to-UART, as seen in Figure 16-3.

Just as the two modems agree to use the same protocols, both the sending and receiving UART chips must have determined to use the same protocol to send and receive data, for communication to take place. The five protocols for digital communication between two PCs, as controlled by their UART chips, are listed in Table 16-4. Figure 16-14 shows the Windows 9x screen where these protocols are set for the UART chip and its COM port. The resulting selections are known as the **port settings**.

TIP

Don't confuse the modem settings with the port settings. Modem settings control modem-to-modem communication, and port settings control UART-to-UART communication.

Table 16-4 Communication protocol between two UART chips

Port Setting	Description	Common Values
Bits per second (port speed)	What will be the speed of transmission in bps?	2400; 4800; 9600; 19,200; 38,400; 57,600; 115,200; 230,400; 460,800; 921,600 bps
Data bits	How many bits are to be used to send a single character of data?	7 or 8 bits
Parity	Will there be error checking, and if so, what will be its format?	Odd, even, or none
Stop bits	What will be the code to indicate that a character (its string of bits) is starting or ending?	1, 1.5, or 2 bits
Flow control	How will the flow of data be controlled?	Xon/Xoff or hardware

The first and last items in this table (speed and flow control) have already been discussed. This section covers the other three settings.

Data Bits Back when most data sent across modems was in ASCII format, the question arose: How many bits are necessary to send one ASCII character? The answer to this question was critical because the maximum number of bits needed to represent one ASCII character is 7 bits, not 8. (To understand this point, see Appendix C, and convert the largest hex value to binary.) Therefore, to transmit in ASCII really requires that only 7 bits be used per character. The choice, therefore, for character transmission is either 7 or 8 data bits. Most often today, you should choose 8 data bits unless you know that you are only transmitting in ASCII.

Parity Parity checking in telecommunications is performed in much the same way that memory on a system board checks parity. When you are using 7 data bits, add an extra bit, which can be 0 or 1 to make either odd or even parity. The receiving UART chip compares the parity to its count of odd or even bits to check the data bits for errors. In most cases today, you don't want the UART chip to use parity checking. Error checking as well as error correction can be better performed by the modem.

16

Stop Bits Whenever the sending UART chip is ready to send a group of data bits (a character) to the receiving UART chip, it puts one start bit in front of the data bits to indicate to the receiving UART chip that a character is starting. In most cases, the UART chip also sends one stop bit to indicate that the character is complete, although two stop bits can be selected.

Installing and Configuring a Modem

A+CORE 1.7

Follow these steps to install an internal modem:

1. Read the modem documentation.
2. Determine which serial port is available on your system.

A+ CORE 1.7

3. Set any jumpers or DIP switches on the modem card. (See your documentation for details about your card. An example is shown in Figure 16-18. Common jumper and DIP switch settings are for COM ports, IRQ, and I/O addresses, and to indicate whether or not the card will use Plug and Play.)

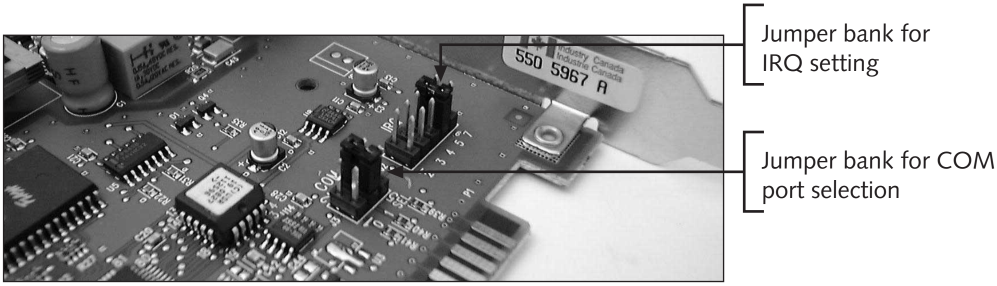

Figure 16-18 A modem will have jumpers to set IRQ and COM values. The default jumper settings should be set to use Plug and Play rather than dictate these values

4. Turn off your computer and remove the case. Find an empty slot, remove the faceplate, and save the screw. Mount the card firmly into the slot, and replace the screw to anchor the card.
5. Replace the cover. (You can test the modem before replacing the cover.)
6. Plug the telephone line from the house into the line jack on the modem. The second RJ-11 jack on the modem is for an optional telephone. It connects a phone so that you can more easily use this same phone jack for voice communication.

For an external modem, follow these steps:

1. You need an RS-232c serial cable to connect the modem to the serial port. If the modem does not come with a cable, don't skimp on price here; buy a good quality cable. Connect the cable to the modem and to the serial port.
2. Plug the electrical cord from the modem into a 110V AC outlet.
3. Plug the telephone line from the house into the line jack on the modem. The second jack on the modem is for an optional telephone.

Turn on your computer and follow these steps to configure the modem under the OS. Begin with Step 1 for Windows NT, with Step 12 for Windows 9x, and with Step 14 for Windows 2000.

1. For Windows NT, click **Start**, point to **Settings**, click **Control Panel**, and then double-click **Modem**. You see the Install New Modem dialog box, as in Figure 16-19. If you want Windows NT to detect and install the modem for you, click **Next** and go to Step 3. If you want to provide the installation disk for the modem, click **Don't detect my modem: I will select it from the list**, and proceed to Step 2.

A+ CORE 1.7

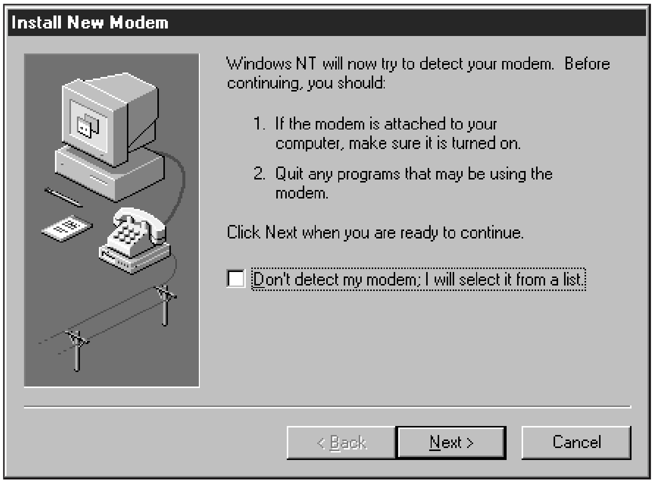

Figure 16-19 Installing a new modem

2. Either select the modem from the list of modems provided by Windows NT or, if you have an installation disk provided with the modem, click **Have Disk** and provide the location of the files. Go to Step 4.

TIP

Sometimes an installation disk has several directories, one for each operating system it supports. For example, for Windows NT 4.0, look for a directory named \NT40.

3. After the modem is detected, Windows NT requests the location of the Windows NT \I386 directory on the Windows NT installation CD-ROM from which it copies the necessary drivers. Place the CD in the drive and enter the location of the directory, using the drive letter of your CD-ROM (for example, D:).
4. After the modem drivers are installed, configure the modem. Click **Start**, point to **Settings**, click **Control Panel**, and then double-click **Modem**. The modem Properties box opens, which looks and works about the same as it does in Windows 9x. Click the installed modem and then click **Properties**.
5. Use the properties listed below unless you have a specific reason to do otherwise (such as to compensate for a noisy phone line).
   - Set the modem speed at the highest value in the drop-down list, which is the highest value supported by this modem.
   - Set the port protocol at "8, No, and 1," which is computer jargon for 8 bits, no parity, and 1 stop bit.
   - Use hardware flow control.

16

A+ CORE 1.7

6. If you want to use Windows NT to make calls without using other software, install Dial-Up Networking. Double-click the **My Computer** icon, and then double-click **Dial-Up Networking**. You see the dialog box illustrated in Figure 16-20, and Windows NT tells you that you can now install the service.

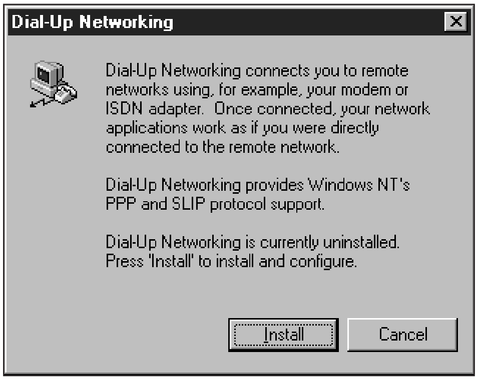

Figure 16-20 Windows NT instructs the user to install Dial-Up Networking before the modem can be used

7. Click **Install**.
8. Windows NT requests the location of the \I386 directory. Insert the CD-ROM and enter the location of the directory.
9. When Windows NT asks you to select the RAS (Remote Access Service, pronounced "razz") device, select the newly installed modem and click **OK** to continue.
10. When you are asked to select the type of communication protocols that you want to use when connected, select two, NetBEUI and TCP/IP (Dial-Up Networking is covered in detail in Chapter 17).
11. Reboot the PC. The configuration is now complete for Windows NT.
12. For Windows 9x, turn on the PC. Windows 9x Plug and Play detects a new hardware device. Allow the OS to identify the modem and install the drivers, or provide your own disk. You might have to boot twice: once to allow Plug and Play to detect the UART and again to detect the modem.
13. After the modem drivers are installed, configure the modem. Use the same method as for Windows NT, beginning in Step 4. The Windows 9x installation is now complete.
14. For Windows 2000, installation is performed as it is for Windows 9x because both OSs use Plug and Play. However, some options in the modem Properties dialog box are slightly different. To configure the modem, click **Start**, point to **Settings**, click **Control Panel**, and double-click the **Phone and Modem Options** icon. When the Phone and Modem Options dialog box opens, click the **Modems** tab. Select the modem and click **Properties**. The modem Properties dialog box opens. Configure the modem using this dialog box.

What can go wrong during modem installation and how to detect and resolve conflicts are covered under the Troubleshooting section later in the chapter. The last step after the modem installation is complete is to test the modem using communications software.

An excellent software utility you can use to test a modem is HyperTerminal, a quick and easy way to make a phone call from a Windows 9x PC. Follow these steps to test your modem using Windows 9x:

1. For Windows 98, click **Start**, point to **Programs**, **Accessories**, **Communications**, and click **HyperTerminal**. For Windows 95, click **Start**, point to **Programs**, **Accessories**, and click **HyperTerminal**.
2. Double-click the **Hypertrm.exe** icon in the HyperTerminal window.
3. When you see the Connection Description dialog box, enter a descriptive name for your connection and select an icon for the shortcut. Click **OK**.
4. Enter the phone number to dial and select the modem from the list of dial-up devices (most likely it's the only entry). Click **OK**.
5. Click **Dial** to make the call. Even if you dial an out-of-service number, you can still hear your modem make the call. This confirms that your modem is installed and configured to make an outgoing call.

COMMUNICATIONS SOFTWARE

You have seen how one modem communicates with another modem and how computer hardware (a UART controlling a COM port) communicates with a modem. You have also seen how one computer's hardware communicates with another computer's hardware (UART-to-UART). Now take this process a step further up the communications layers to where hardware communicates with an OS, which communicates with communications software, as shown in Figure 16-3. The UART chip is sending and receiving data only because the software on the PC is communicating with it. Windows 9x, Windows NT, and Windows 2000 support communication using modems without any other communications software. These operating systems communicate with modems by using the **Telephony Application Programming Interface (TAPI)**, a standard jointly developed by Intel and Microsoft, used by Windows to connect a PC to telephone services. **Telephony** is a term describing the technology of converting sound to signals that can travel over telephone lines (the technology of telephones), and TAPI is a type of API (application programming interface) that Windows can call when it needs to make a telephone connection.

Even though you can make phone calls from your PC using only the operating system, using an application specifically designed to manage communications enhances communication in several ways, as you will see later in the chapter. Two examples of communications software programs are ProComm Plus and pcANYWHERE. These two applications software programs can be used to send files back and forth between computers, control remote computers, and perform a variety of other communications tasks.

This section looks at how communications software communicates with a modem (by way of a UART chip) and at how communications software on one PC communicates with the same or similar software on another PC.

Software-to-Modem Communication

In previous sections you have seen how one modem communicates with another modem, and how a PC and a modem communicate with each other, using the RS-232c standard for out-of-band signaling. Sometimes the commands that a PC needs to send to a modem cannot fit into the pinouts provided by the RS-232c standard, such as the command to make a call or what phone number to dial. This type of information needs to be sent to a modem as characters, but the modem must distinguish between the characters it is receiving from the computer that are commands and the characters that are simply being sent along as data and don't need to be interpreted.

One of the pioneers in modem communications, Hayes Microcomputer Products, developed a language for PCs to use to control modems. Hayes did not patent or copyright the language, so most modems today are built to understand this language. Any modem that contains the logic to understand this language is said to be Hayes-compatible, and the language has become a *de facto* standard. (A **de facto standard** is a standard that does not have official backing, but is considered a standard because of widespread use and acceptance by the industry.)

The Hayes language for modem control is called the **AT command set** because, when the modem is receiving commands, each command line is prefaced with AT for ATtention. A modem that uses this language stays in command mode at any time that it is not connected to another modem. When a modem is in command mode and bits and bytes are sent to it from a PC, the modem interprets the bytes as commands to be followed, rather than as data to be sent over a phone line. It leaves command mode when it either receives an incoming call or dials out, and returns to command mode when a call is completed or a special escape sequence is sent to it by its computer.

Other manufacturers of modems have added to the Hayes AT command set, but Table 16-5 lists a few of the core AT commands that most modems understand. The commands that begin with the ampersand character (&) are part of the extended command set; the others are part of the basic command set. When a modem is in command mode, it responds to each command with OK or gives the results after performing the command. You can type a command from a communications software window to be executed immediately or enter a command from a dialog box for the modem configuration to be executed later, when the modem makes a call.

Table 16-5 AT commands for Hayes-compatible modems

Command	Description	Some Values and Their Meanings
+++	**Escape sequence:** tells the modem to return to command mode. You should pause at least 1 second before you begin the sequence. After you end it, wait another second before you send another command. Don't begin this command with AT.	
On	**Go online:** tells the modem to return to online data mode. This is the reverse command for the escape sequence above.	O0 Return online O1 Return online and retrain (perform training or handshaking again with the remote modem)
A/	**Repeat last command:** repeat the last command performed by the modem. Don't begin the command with AT, but do follow it with Enter. Useful when redialing a busy number.	
In	**Identification:** instructs the modem to return product identification information	I0 Return the product code I3 Return the modem ROM version
Zn	**Reset:** instructs the modem to reset and restore the configuration to that defined at power on	Z0 Reset and return to user profile 0 Z1 Reset and return to user profile 1
&F	**Factory default:** instructs the modem to reload the factory default profile. In most cases, use this command to reset the modem rather than using the Z command.	
A	**Answer the phone:** instructs the modem to answer the phone, transmit the answer tone, and wait for a carrier from the remote modem	
Dn	**Dial:** tells the modem to dial a number. There are several parameters that can be added to this command. A few are listed on the right.	D5551212 Dial the given number D, Causes the dialing to pause DP Use pulse dialing DT Use tone dialing DW Wait for dial tone D& Wait for the credit card dialing tone before continuing with the remaining dial string
Hn	**Hang up:** tells the modem to hang up	H0 Hang up H1 Hang up and enter command mode
Mn	**Speaker control:** instructs the modem as to how it is to use its speaker	M0 Speaker always off M1 Speaker on until carrier detect M2 Speaker always on

Table 16-5 AT commands for Hayes-compatible modems (continued)

Command	Description	Some Values and Their Meanings
Ln	**Loudness:** sets the loudness of the modem's speaker	L1 Low L2 Medium L3 High
Xn	**Response:** tells the modem how it is to respond to a dial tone and busy signal	X0 Blind dialing; the modem does not need to hear the dial tone first and will not hear a busy signal X4 Modem must first hear the dial tone and responds to a busy signal (this is the default value)

For example, to use HyperTerminal to control a modem using the AT command set, follow these steps.

1. For Windows 98, click **Start**, point to **Programs**, **Accessories**, **Communications**, and click **HyperTerminal**. For Windows 95, click **Start**, point to **Programs**, **Accessories**, and click **HyperTerminal**.
2. Double-click the **Hypertrm.exe** icon in the HyperTerminal window.
3. When the Connection Description dialog box opens, click **Cancel**. You see an empty HyperTerminal window. Type **AT** and press **Enter**. The modem responds with OK to acknowledge the command session. See Figure 16-21.

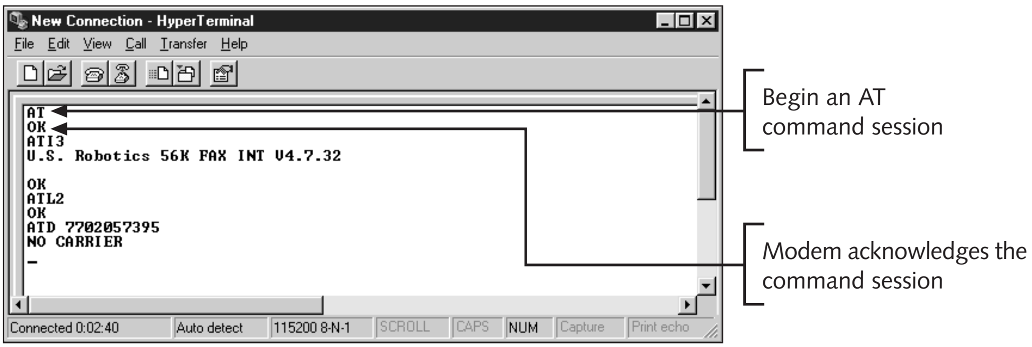

Figure 16-21 HyperTerminal can be used to control a modem using the AT command set

4. Enter any AT command. For example, in Figure 16-21, the ATI3 command causes the modem to report its ROM version, the ATL2 command sets the loudness to medium, and the ATD command followed by a phone number causes the modem to dial a number. Notice in the figure that the modem responds that no modem was connected on the other end (NO CARRIER).

Table 16-6 shows an example of an interchange between a modem and a user. Other examples of AT commands and their meanings are listed in Table 16-7.

Table 16-6 An example of a dialog between a user and a modem

Source	Command or Response	Description
From user	ATD 5551221 [enter]	Dial the given number.
From modem	CONNECT 19200	Modem responds with the agreed-on bps. At this point, you can transfer data using a utility provided by the communications software. Then wait at least 1 second before the next command.
From user	+++	Escape sequence telling the modem to return to command mode (then pause 1 second).
From modem	OK	Modem responds by giving you the OK response.
From user	ATH0 [Enter]	Disconnect the line.
From modem	OK	Modem responds by giving you the OK response.

Table 16-7 Some examples of AT commands

Command	Description
ATDT 5552115	Dial the given number using tone dialing.
ATDP 5552115	Dial the given number using pulse dialing.
ATD 9,5552115	Dial 9 and pause, then dial the remaining numbers (use this method to get an outside line from a business phone).
AT &F1DT9,5552115	Restore the default factory settings. Dial using tone dialing. Pause after dialing the 9. Dial the remaining numbers.
ATM2L2	Always have the speaker on. Set loudness of speaker at medium.
ATI3	Report the modem ROM version.

Even though you can communicate with a modem using AT commands, most often when working with modems, you are using communications software that is providing a more user-friendly interface than just a window for AT commands. For example, when using pcANYWHERE, you can tell the software to dial up a remote computer by clicking on a button and typing a phone number to dial. The software performs the dial-up in the background for you by sending the appropriate AT commands to the modem.

Using pcANYWHERE for Windows 3.x, follow the steps below to establish a connection to a remote PC. (The Windows 9x version of pcANYWHERE works similarly, except that the modem dialog box showing AT commands does not appear.)

1. Double-click the **pcANYWHERE** icon in Program Manager. The pcANYWHERE opening screen appears, as in Figure 16-22.

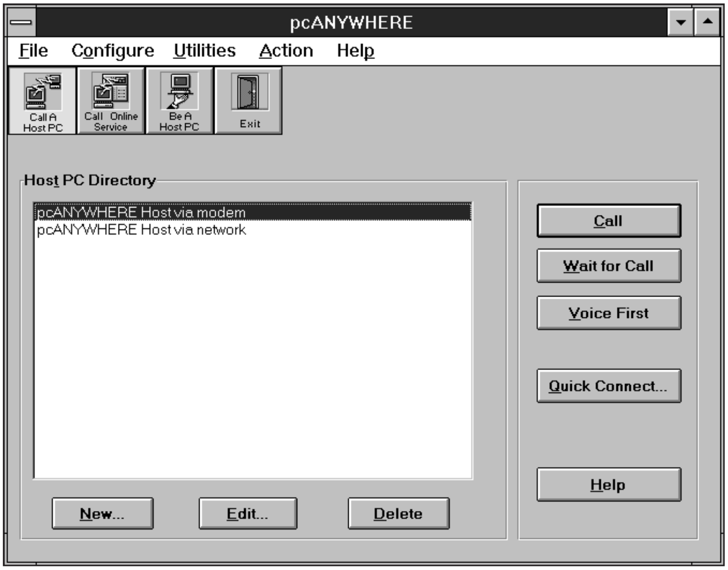

Figure 16-22 Opening screen of pcANYWHERE for Windows 3.1

2. Click **Call a Host PC** and select **pcANYWHERE Host via modem** from the Host PC Directory. Click **Call**.
3. Enter the phone number to dial and click **OK**. pcANYWHERE does the rest. The Connecting dialog box opens, as in Figure 16-23, showing the dialog between the software and its modem. Notice in the Modem dialog box of Figure 16-23 that some of the AT command strings contain "S*n* = number," where *n* is a number. These commands set the modem's internal registers, which are memory locations in the modem where it temporarily keeps configuration information. For example, the AT command S7 = 30 in Figure 16-23 says to store the value 30 in modem register 7. Modem register 7 is used to keep the number of seconds that the modem is to wait for a carrier from the other modem before assuming that the modem is not there. The value is set to 30 seconds. For a complete listing of the modem registers and the values they support, see your modem manual.

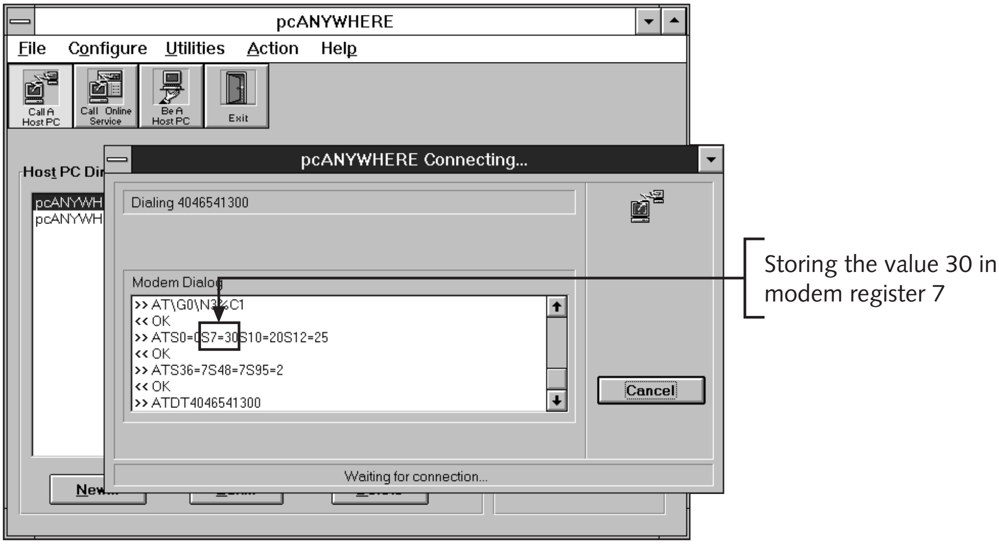

Figure 16-23 Sample dialog between the communications software and its modem shows modem registers being set

4. After the connection is made, pcANYWHERE creates a window on your screen that is an exact replica of the remote PC's screen.

Software-to-Software Communication

Even though you know that software cannot communicate directly with software on another computer without going through modems, logically this fact can be masked so that there can be virtual communication between the software programs. Return to the newspaper analogy in Figure 16-1: The distribution center at the newspaper press headquarters receives a request for papers from a remote distribution point in the city. The center fills the order and responds that the newspapers are on the way. The truck and road systems are involved in this transaction, yet the two distribution points communicate and do business at a high level where trucks and the road system supporting them are not even considered; however, they are part of the transaction, but are transparent to the two distributors.

16

This concept is also true of two communications applications communicating. One application sends its data to another application, which receives the data and responds. This higher communication layer is the beginning of the software realm of data communication. There are basically two ways that software communicates with other software:

- **Remote control.** In this mode, the remote PC controls the host PC. The remote PC sends commands to the host PC. The host PC uses these commands to execute software on the host PC and passes the results of the commands back to the remote PC. This method passes commands from the remote PC to the host. The host PC cannot pass commands to the remote PC.

- **Data transfer.** In this mode, the remote PC requests data from the host computer, and the host computer sends the requested data to the remote PC. File transfer is one example of this type of communication. This method passes requests for data from the remote PC to the host. The host computer cannot request data from the remote PC. (Downloading a file from an Internet Web site is an example of data transfer.)

The first method is usually slower than the second method, but offers more power to the remote PC. This section looks at an example of each type of software-to-software communication, using pcANYWHERE.

File Transfer with pcANYWHERE

Sharing data between two PCs is one of the most common tasks of communications software. Most communications applications provide file-transfer utilities that have their own look and feel, but the basics of file transfer are the same from one utility to another. The file-transfer function of pcANYWHERE for Windows 9x is the example used below. pcANYWHERE on one computer can make a connection to another PC in one of three ways:

- A remote PC can call a host PC.
- A host PC can call a remote PC.
- A PC can call an online service.

In the explanation below, the terminology used by pcANYWHERE is followed. The two PCs are called the host PC and the remote PC. The host follows the commands of or processes requests for data from the remote PC. The first instance listed above is used for the example below: a remote PC calling a host PC. If you are sitting at a PC making a call to another PC, your PC is called the remote PC, even though it is not "remote" to you, but rather is your local PC; the other PC is called the "host" PC. The connection is made as follows:

1. Call the host PC. The connection is made at the modem-to-modem level. A window opens that is a replica of the host PC's screen. An example is shown in Figure 16-24.
2. Select the **File Transfer** option. The window illustrated in Figure 16-25 opens.
3. In this pcANYWHERE File Manager window, you see your directories and files on the left side of the window (called the Remote side) and the files on the other PC on the right (called the Host side). Commands are listed at the bottom of the window. To copy a file from the Remote side to the Host side, select the file on the left and drag it to the right side, or can use the Send button on the bottom of the window.
4. Exit the utility by selecting **File**, **Exit** from the menu at the top of the window.

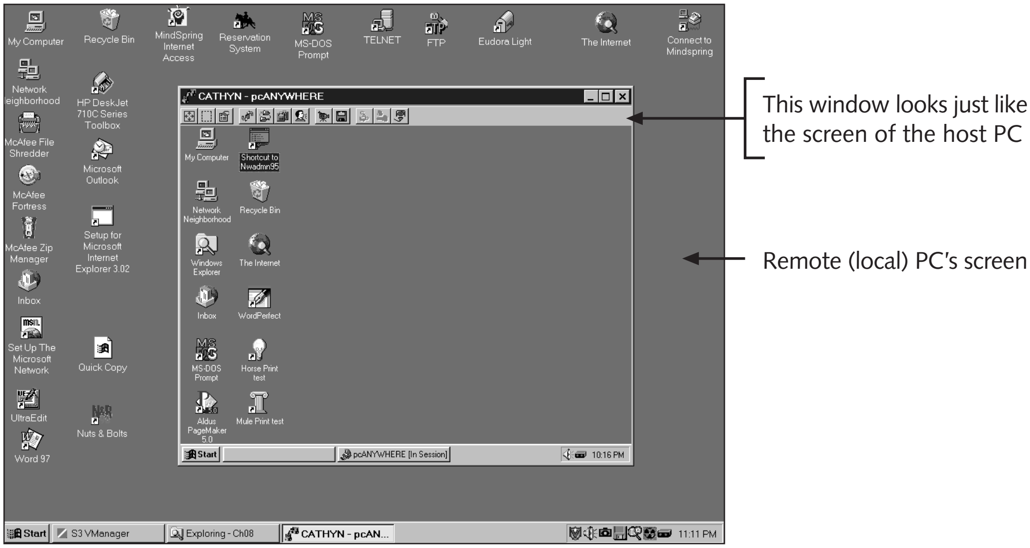

Figure 16-24 pcANYWHERE provides a window on the remote PC that replicates the screen on the host PC. From this window, the remote user can control the host PC.

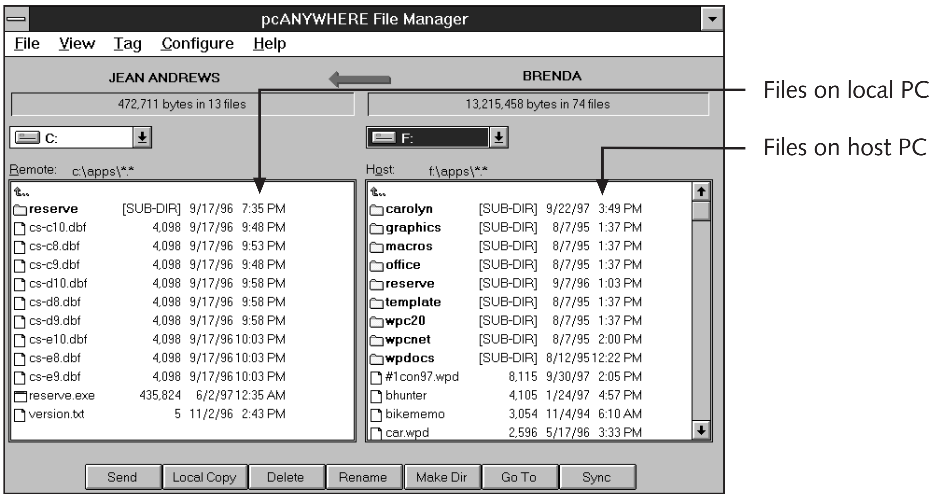

Figure 16-25 The pcANYWHERE file transfer utility is called the pcANYWHERE File Manager

Remote Control with pcANYWHERE

One very useful tool for software communication, especially for a PC support person, is remote control. With remote control, a person sitting at one PC (called the remote) can dial another PC (called the host) and remotely control the other PC. The user can execute

software on the host PC just as though he or she were sitting at the host PC, and even reboot the host PC. Help-desk personnel find this kind of control very useful when supporting a user and PC at a remote location. A person working from home or off-site can dial into his or her computer at work and perform tasks on that PC that can also be performed while sitting in front of it, although the speed of response does limit how productive that work can be.

In Figure 16-24, a connection is established between the remote (local) and the host (the other end). If the Host window shown in the figure is the active window, any mouse movement or keyboard strokes that are performed at the remote PC are passed to the host computer to be executed. If the Host window is not active, then the user is controlling his or her own computer locally.

Remote control requires that both computers have pcANYWHERE installed. When you purchase pcANYWHERE, you are purchasing two licenses, one for the remote PC and one for the host. ProComm Plus also offers a remote control utility with a similar licensing policy. With both applications, a PC can be set up to be either the remote or the host, but can't be both at the same time. The host serves the remote, passing data to it or performing commands it receives from the remote. The remote PC has more control over what is being done than does the host.

To make your computer a host computer, you must set pcANYWHERE to be a host and leave the application open and waiting for a call. To do so, follow these steps:

1. Using Windows 9x, start pcANYWHERE.
2. Click **Be a Host PC**. The dialog box shown in Figure 16-26 opens.
3. To require a password for the caller or limit the caller to only certain directories or drives on your PC, click **Settings**.
4. After you specify settings, click **Wait for Call**. pcANYWHERE initializes the modem, reduces itself to an icon and waits, as in Figure 16-27.
5. You can use the PC in any other way while the PC is listening for a call. When a call from a remote PC is in progress, you can watch what is happening at the host end.

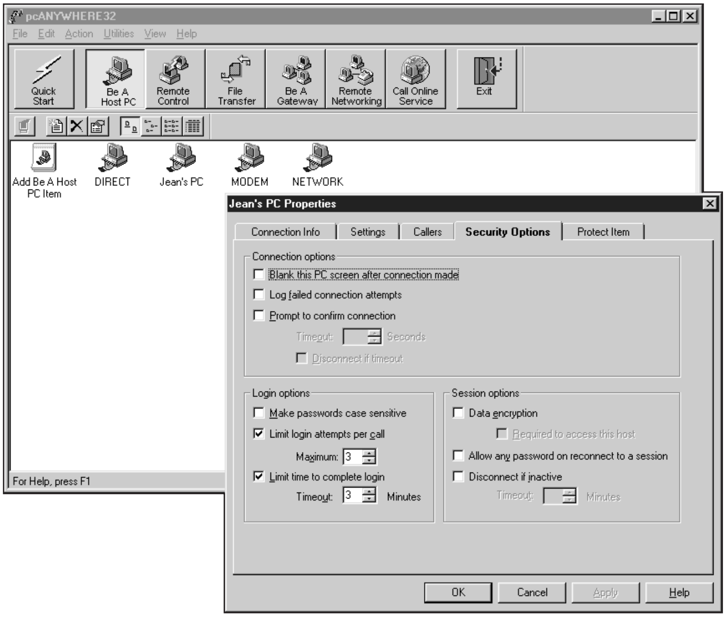

Figure 16-26 Setting up a PC to be a host using pcANYWHERE

Figure 16-27 "pcANYWHERE waiting" in the taskbar indicates that this host PC is waiting for an incoming call

TROUBLESHOOTING GUIDELINES

A+ CORE 2.1

This section provides a guide to solving problems with modems and communicating over phone lines. Some keys to troubleshooting are: determine what works and what doesn't work, find out what has worked in the past that doesn't work now, and establish what has changed since things last worked. Much of this can be determined by asking the user and yourself questions and by trying the simple things first. Below is a list of problems you may encounter with your modem and suggestions on how you can proceed.

16

The modem does not respond.

1. Make sure the modem is plugged into the phone jack.
2. If you are using an external modem, make sure it is plugged into the computer and that the connection is solid.
3. There are two RJ-11 ports on a modem. Check that the phone line from the wall outlet is connected to the line-in port.

A+CORE 2.1

4. Plug a phone directly into the wall jack you are using and make sure that there is a dial tone.
5. If necessary, make sure to instruct the modem to dial an extra character to get an outside line, such as 9 or 8.
6. If this is a new installation that has never been used before, check these things:
   - Make sure the modem is set to the same COM port and IRQ that the software is set to.
   - Make sure that no other device is configured to the same COM port or IRQ as the modem.
   - For an internal modem, check that the DIP switches and jumpers agree with the modem properties in the OS.
   - For an internal modem, using CMOS setup, disable the COM port the modem is set to use so there will be no conflicts. For an external modem, verify that the COM port the modem is using is enabled.
   - If you are using an internal modem, try installing it in a different expansion slot. If you are using an external modem using a serial port card, move the serial port card to a different slot and try to install the modem. If you are using an external modem, substitute a known-good serial cable.
   - Check that the software correctly initialized the modem. If you did not give the correct modem type to the software, it may be trying to send the wrong initialization command. Try AT&F. (Under Windows 9x, click **Start**, point to **Settings** and click **Control Panel**. Double-click **Modems**. Select the modem and click **Modem Properties**, **Connection**, **Advanced**. The dialog box in Figure 16-28 opens. Enter the AT&F command under Extra settings.) Retry the modem.
   - Make sure you have enough RAM and hard drive space. Then close all other applications currently running, reboot the PC, and try the modem again.

The modem says there is no dial tone, even though you can hear it.

1. Make sure the phone cord from the wall outlet is plugged into the line jack on the modem.
2. The modem might not be able to detect the dial tone even if you can hear it. Try unplugging any other equipment plugged into this same phone line, such as a fax machine.
3. Try giving the ATX0 command before you dial. Enter the command under Advanced Settings, as in Figure 16-28. If that doesn't help, then remove the ATX0 command.
4. Straighten your phone lines! Don't let them get all twisted and crossed up with other heavy electrical lines.

A+ CORE 2.1

5. If there has been a recent lightning storm, the modem may be damaged. Replace the modem with one you know works.

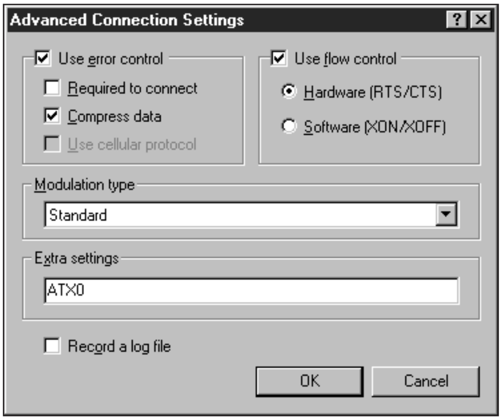

Figure 16-28 The Extra settings box allows you to send extra AT commands to the modem on any call

The modem dials and then says that the other end is busy, even when you know that it is not.

1. This can happen with international calls if the modem does not recognize the signal as a ring. Try giving the ATX0 command first.
2. Straighten the phone lines and remove extra equipment, as described above.

The sending modem and the receiving modem take a very long time to negotiate the connection.

1. This is probably because of a noisy phone line. Try calling again or using a different number.
2. Remove other equipment from your line. A likely suspect is a credit card machine.
3. Try turning off data compression and try again.
4. Turn off error correction and try again.
5. Try forcing your modem to use a slower speed.

During a connection, it sounds as if the handshaking starts all over again. Modems normally do this if the phone line is noisy and would cause a lot of data to become corrupted; it's called retraining, and it sometimes can solve the problem as the modems renegotiate, compensating for the noisy line. Do the things listed above to clear your line of equipment and twisted phone lines.

A+CORE 2.1

File transfers are too slow. Make sure your modem is configured to use data compression, if possible.

The modem loses connection at odd times or is slow.

1. Check the communications software for the speed assigned to it. Many times people set the communications software speed for the modem speed instead of for what the software is asking for, the port speed, which should be about four times the modem speed.
2. You may have a noisy phone line. Try the connection using the same brand and model of modem on both lines. If performance is better, the problem is most likely the phone line.
3. Is the phone line from the modem to the jack too long? About 4 feet is the limit; otherwise, electromagnetic interference may be the problem.
4. Straighten the phone lines and clear the line of any extra equipment.
5. Reinstall the modem. Allow Windows 9x to detect the modem for you and install its own drivers.

The modem drops the connection and gives the NO CARRIER message.

1. Most likely the connection was first dropped by the remote modem. Is someone trying to use a phone extension on this line?
2. Disable call waiting. To do this, put *70 before the dialing number. Some communications software has a setting to disable call waiting. If not, you can put these three characters in the Extra settings box of Advanced Connections Settings (see Figure 16-28).
3. Remove extra equipment from the line and straighten the phone lines.
4. Check the modem settings and make sure "Error control required to connect" is not checked.
5. Try using a different modulation type under Advanced Connection Settings of your modem properties.
6. The remote modem may not support the high speeds used. Try reducing the port speed to 9600 or lower.

Whenever the weather is bad, the connection disconnects often. This is caused by a dirty phone line. Remove any extra equipment and straighten the lines.

Whenever large files are downloaded, some of the data is lost. Make sure that hardware flow control is on, and that software flow control is off, for the software, the COM port, and the modem. (Use software settings options, the COM port Properties box, and the modem Properties box.)

A+ CORE 2.1

The connection fails whenever large files are uploaded or downloaded. There may be a buffer overflow. Try these things to gain better control of data flow:

1. Make sure that hardware flow control is on, and that software flow control is off, for the software, the COM port, and the modem.
2. Is the serial port speed set too high for the UART chip you have? Lower the port speed.
3. For an external modem, try a different serial port cable.

You get nothing but garbage across the connection.

1. Check the port settings. Try 8 data bits, no parity, and one stop bit (8, No, and 1).
2. Slow down the port speed.
3. Slow down the modem speed.
4. Try a different modulation type.

FASTER THAN PHONE LINES

A+ CORE 6.1

The speed of communicating data is constantly improving. Looking back at Figure 16-3, you can see that no matter how fast communication is between the computer and its modem, the speed between one modem and another can be no faster than the limited speed of the regular analog phone lines to which they are connected. You also learned in this chapter that phone lines most often become digital once they reach a central office of the phone company or some other centralized location. The phone company transports voice and data digitally over long distances and then converts it back to an analog signal just before it reaches the customer location, which is usually done at the customer's central office.

The problem with slow analog lines can be greatly improved by making the phone lines digital all the way from one customer to the next. This was first done for large commercial customers. One example of a digital line is called a T1 line, which carries the equivalent of 24 phone circuits and can transmit data at 1.5 million bps. Prices for T1 lines vary and are somewhere around $1000 per month. These lines are sometimes installed as private circuits connecting two locations of the same company.

16

A T1 line is too expensive for personal or small business users, so several technologies have emerged to compete for the home and small business market for high-speed data transmission. The data transmission capacities for several of these technologies are listed in Table 16-8. When referring to digital data communication, data transfer capacity is called **bandwidth**.

TIP

When referring to analog data communication, bandwidth has a different meaning than it does when applied to digital communication. With analog communication, bandwidth is the range of frequencies that can travel over the analog line. For example, regular telephone lines can accommodate frequencies between 300 Hz and 3,300 Hz, so the bandwidth of a regular phone line is 3,000 Hz.

Table 16-8 Bandwidth technologies for personal and small business users

Technology	Access Method	Attainable Speeds	Comments
Regular phone line	Dial-up	Up to 53 Kbps	POTS — "plain old telephone service"
ISDN	Dial-up	64 Kbps to 128 Kbps	Requires a leased line from phone company. It can be used by a medium-sized business to access an ISP.
DSL	Direct connect	Varies greatly; 1 Mbps upstream and up to 32 Mbps downstream	Requires a leased line from phone company. There are several versions of DSL on the market.
Cable modem	Direct connect	512 Kbps to 5 Mbps	Uses TV cable system to provide home or small business access to ISP
Satellite	Direct connect	400 Kbps	Only works downstream; upstream transmission requires a dial-up

Integrated Services Digital Network (ISDN)

A+ CORE 6.1

A technology developed in the 1980s that uses regular phone lines and is accessed by a dial-up connection was developed using an accepted international standard called **Integrated Services Digital Network** or **ISDN**. An ISDN line is fully digital and consists of two channels, or phone circuits, on a single pair of wires. Each line can support speeds up to 64,000 bps. The two lines can be combined so that, effectively, data travels at 128,000 bps, which is about five times the speed of regular phone lines.

Because ISDN lines are designed for small business and home use, the two lines can support voice communication, fax machines, and computers. Logically, the two circuits are two phone lines, which can each have different phone numbers, although most often only one number is assigned to both lines. Because an ISDN line must have little noise on it, only a single jack for the line—which initially connects to one device—is allowed at a customer location.

In order to use an ISDN line at your business or home, you must have these things:

- An ISDN line leased from the phone company
- An ISDN device on your computer (comparable to a modem for a regular phone line)
- ISDN software on your PC to manage the connection

If you plan to use an ISDN line to access the Internet, then, in order for you to see a performance gain, your service provider must also have an ISDN line. If you plan to use the ISDN line for telecommuting, then your place of business must also have ISDN in order for performance to improve.

The single ISDN device that connects to the ISDN line at your home can be an expansion card inside your PC or can be an external device. Communications software, the OS, and computer hardware relate to an ISDN device for digital phone lines just as they relate to a modem for analog phone lines (see Figure 16-3). The communications software and the OS must support the ISDN device. If the device is external and using the COM port on the computer system, then the UART chip controlling that COM port does not make a distinction between communicating with an ISDN device and with a modem, since all its communication is digital in either case. There are three choices as to how you can connect to ISDN:

- **Internal card.** An internal card is less expensive than the other two choices, but limits the use of the ISDN to when your computer is on.
- **External device.** An external device requires a connection to your PC. If you connect the device by way of your serial port, you have a bottleneck at the serial port; the device can communicate to your PC only as fast as the serial port speed.
- **External device and network card.** You can use an external device connected to your PC by way of a network card. The price is higher, but this solution offers the most advantages: the PC does not have to be on to use the ISDN line, and the network card is faster than a serial port.

Figure 16-29 shows one setup for an ISDN external device. The external ISDN device can also function as a bridge between a LAN in your building and the ISDN line. (In networking, a bridge is a device that connects two networks so that communication can take place between them.) Every PC would then connect to the ISDN line by way of its network card, which is also its access to the LAN. Some of these external ISDN devices also supply ordinary phone jacks so that ordinary telephones can also be connected to the ISDN line without having to go through a PC in your building.

The ISDN device, be it internal or external, in North America is technically an NT1 (network termination 1) device, but the term heard most often in referring to this device is a terminal adapter (TA). The two major manufacturers of TAs in the U.S. are Eicon Technologies and 3Com. (See their Web sites at *www.eicon.com* and *www.3com.com* for more information.)

You may hear an external TA called an ISDN modem or an ISDN box. An internal TA may be called an ISDN card or an ISDN modem. Call it a box or a card or a device, but calling it an ISDN modem is not correct! A modem converts digital to analog and analog to digital. An ISDN circuit is digital all the way. No modems are needed.

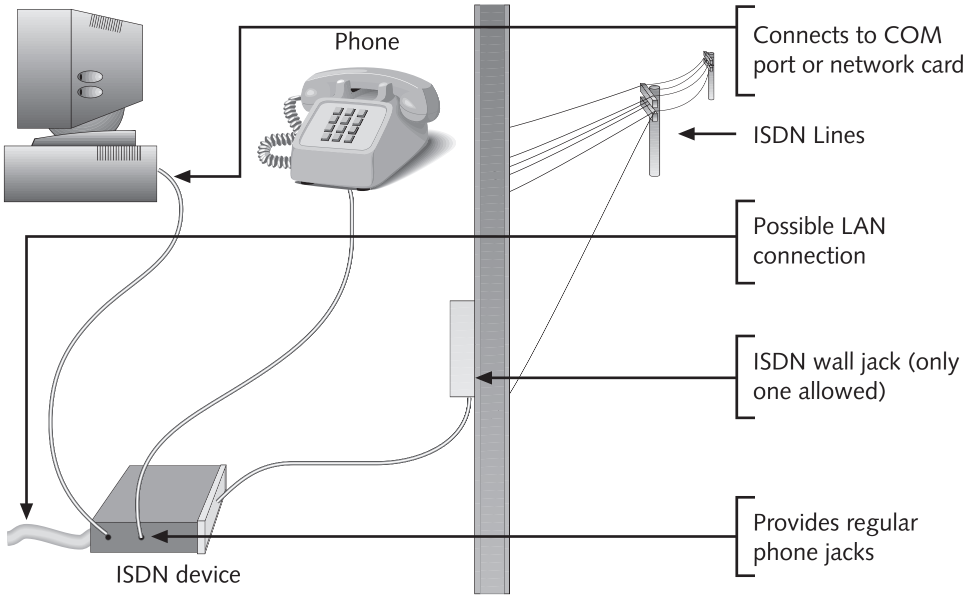

Figure 16-29 An external ISDN device serves as a connection point for PCs and telephones

Cable Modem

A+ CORE 6.1

Regular phone lines and ISDN both require a dial-up connection. In moving to the next generation of data transmission for the home and small business, the choice is a direct connection and speeds measured in Mbps (million bits per second) rather than Kbps (thousand bits per second). A direct connection means that the line is always up rather than having to be established as a connection with a dial-up. **Cable modem**, a popular technology that is direct connect, uses cable lines that already exist in millions of households in the U.S. Just as with cable TV, cable modems are always connected. Simply turn on the PC and you're up. Cable modems use a technology called **Data Over Cable Service Interface Specifications (DOCSIS)**.

With cable modem, you install an Ethernet network interface card in your PC. When the cable company installs the service in your home, they provide an external modem that converts the analog signal coming over the cable to digital before it is sent to the Ethernet NIC in your PC. The modem designed for the DOCSIS interface is likely to be leased to you as part of the cable modem service.

A very few cable companies don't provide upstream service (data flowing *from* your PC *to* your ISP) by cable. The connection downstream (data flowing *from* the ISP *to* your PC) is a direct connect by cable, but the service upstream is by regular dial-up phone lines. This means that you can receive data over the cable, but to transmit, you must use a regular dial-up. Be sure you understand what you're getting before you lease.

A+ CORE 6.1

When you lease cable modem service, you are most likely also agreeing to use the service provider as your ISP. Two popular cable modem providers are @Home and MediaOne Express. See their Web sites at *www.home.net* and *www.mediaoneexpress.com* for more information. The cost for cable modem service, including ISP cost, is in the range of $35–$90 per month. How to connect to the Internet using cable modem is covered in the next chapter.

Digital Subscriber Line (DSL)

In the race to produce a fast data transmission technology that is affordable for home use and offers a direct connection rather than a dial-up, the telephone industry has developed several technologies, which are collectively called **Digital Subscriber Line** or **DSL**. (ISDN is an early example of DSL.)

One prominent version of DSL is **Asymmetric Digital Subscriber Line (ADSL)**, which is 50 times faster than ISDN and is direct connect. (Asymmetric refers to the fact that upstream transmission is not necessarily run at the same speed as downstream transmission.) When using the Internet, most transmission is downstream (downloading Web pages), so the asymmetric technology is a viable option for home use if the emphasis is on using the Internet. ADSL uses a new standard for transmission called **G.Lite** sponsored by ITU. To have a DSL connection, you must lease the line from the phone company, which provides a converter box on-site. From the box, the line connects to an Ethernet NIC in your PC just like cable modem. The cost of an ADSL line varies greatly, anywhere from $75 to $850 per month, depending on your location. How to connect to the Internet using DSL is covered in the next chapter.

Satellite

One last way to attain high-speed data transmission is by using satellites. You lease the service from a provider and mount a satellite dish on your premises. One service provider is DirecPC Satellite Service by Hughes (see the Web site *www.direcpc.com)*. Using a satellite connection for downstream transmission of data is not a good option unless you need high-speed transmission and live in a remote location that doesn't offer other alternatives. The installation can be complicated and requires a dial-up connection for data to travel upstream.

CHAPTER SUMMARY

- Communicating over phone lines involves both virtual communication and direct communication. Virtual communication takes place between counterpart layers at each end of a transmission, and direct communication occurs between adjacent layers.
- A modem is a device used to convert digital data from a PC to analog signals suitable for transmission over phone lines, and to convert analog data from phone lines back to digital signals for a PC.

- When two modems first connect, they must decide how data will be transmitted. This process is called training or handshaking. The handshaking between two modems can be heard as hissing sounds when the two modems first connect.
- Computers communicating through modems are called data terminal equipment (DTE). The modems are called data communications equipment (DCE).
- Modems can perform data compression to speed up transmission, and error correction to ensure the integrity of the data.
- The speed that data can travel over phone lines is called modem speed or line speed and is measured in baud rates or bits per second (bps).
- The limitation of modem speeds is partly determined by the analog quality of phone lines and the way data is converted to digital signals during transmission over the phone lines.
- Modem standards have been set by CCITT (Comité Consultatif Internationale de Télégraphique et Téléphonique), and are now called either CCITT standards or ITU standards.
- Modem standards include standards for speed, data compression, and error correction.
- The protocols used by modems are factory-set into the modem's firmware, but can be partially controlled by settings in the operating system or communications software.
- Error correction performed by modems is done by dividing data into packets or frames and calculating a checksum on each packet. The checksum is calculated again at the receiving end. If the two checksums differ, another transmission is requested by the receiving modem.
- Overall transmission speed is determined by the port speed, which is the speed of the UART chip controlling the communications port used by the modem, and the line speed, which is the speed from modem to modem over phone lines.
- Both internal and external modems use a UART chip to control the transmission of digital data from the computer.
- The method that a receiving modem or PC uses to stop and start the flow of data to it is called flow control.
- Flow control can be performed by a computer or by a modem. Two methods of flow control are software flow control and hardware flow control. Hardware flow control is the preferred choice.
- Serial ports use the RS-232c standard for communication. Hardware flow control uses two of the connections in the RS-232c standard.
- The UART chip controls data transmission speed, parity checking, start and stop bits, and flow control.
- Communications software can either provide remote control to a host PC or pass data from one PC to another. Remote control is usually the slower of the two methods.

- Most communications software communicates to modems using a modem language developed by Hayes called the AT command set. Modems that use this language are said to be Hayes-compatible.
- Some technologies that offer higher data transmission speeds than regular phone lines are cable modem, ISDN, ADSL, and satellite.
- ISDN is a dial-up connection. Cable modem, ADSL, and satellite are direct connections.
- ISDN is a faster alternative to regular analog phone lines because it is digital and provides two lines rather than only the single line provided by regular phone lines.
- In order to benefit from using ISDN technology, both the sending and receiving computers must have an ISDN connection. Each computer must use an ISDN device and ISDN software.
- A cable modem is leased from a cable television company and usually comes bundled with service from an Internet service provider.
- A cable modem requires an external modem to receive the incoming signal that connects to an Ethernet NIC in your PC.
- ADSL is about 50 times faster than ISDN. It connects to your PC by way of an Ethernet NIC.
- Satellite data transmission is only for downstream transmission. Upstream transmission must be by some other method such as dial-up on a regular phone line.

KEY TERMS

ADSL (asymmetric digital subscriber line) — A method of data transmission over phone lines that is digital, allows for a direct connection, and is about 50 times faster than ISDN.

AT command set — A set of commands used by a PC to control a modem. AT is the ATtention command, which alerts a modem to prepare to receive additional commands. For example, ATDT means attention and listen for a dial tone.

Audio/modem riser (AMR) — A specification for a small slot on a system board to accommodate an audio or modem riser card. A controller on the system board contains some of the logic for the audio or modem functionality.

Bandwidth — For digital data transmission, the data transfer capacity (for example, a T1 line has a bandwidth of 1.544 Mbps). For analog data transmission, the difference between the highest and lowest frequency that the technology accommodates (for example, a regular telephone line has a bandwidth of 3,000 Hz).

Baud rate — A measure of line speed between two devices such as a computer and a printer or a modem. This speed is measured in the number of times a signal changes in one second. *See* bps.

bps (bits per second) — A measure of data transmission speed. (Example: a common modem speed is 56,000 bps or 56 Kbps.)

Cable modem — A method of data transmission over cable TV lines that requires a modem and an Ethernet network interface card to receive the transmission.

Carrier — A signal used to activate a phone line to confirm a continuous frequency; used to indicate that two computers are ready to receive or transmit data via modems.

Checksum — A method of error checking transmitted data, whereby the digits are added up and their sum compared to an expected sum.

CCITT (Comité Consultatif Internationale de Télégraphique et Téléphonique) — An international organization that was responsible for developing standards for international communications. This organization has been incorporated into ITU. *See* ITU.

Communication and networking riser (CNR) — A specification for a small expansion slot on a system board that accommodates a small audio, modem, or network riser card. Part of the logic for the card is contained in a controller on the system board.

Data communications equipment (DCE) — The hardware, usually a dial-up modem, that provides the connection between a data terminal and a communications line.

Data terminal equipment (DTE) — This term refers to both the computer and a remote terminal or other computer to which it is attached.

De facto standard — A standard that does not have an official backing, but is considered a standard because of widespread use and acceptance by the industry.

Demodulation — When digital data that has been converted to analog data is converted back to digital data. *See* Modulation.

Digital signal — A signal that has only a finite number of values in the range of possible values. An example is the transmission of data over a serial cable as bits, where there are only two values: 0 and 1.

Digital subscriber line (DSL) — A type of technology that is used by digital telephone lines that direct connect rather than dial-up.

DOCSIS (Data Over Cable Service Interface Specifications) — The communications standard used by cable modems.

Error correction — The ability of some modems to identify transmission errors and then automatically request another transmission.

Flow control — When using modems, a method of controlling the flow of data from a sending PC by having the receiving PC send a message to the sending device to stop or start data flow. Xon/Xoff is an example of a flow control protocol.

Frame — A small, standardized packet of data that also includes header and trailer information as well as error-checking codes.

Full-duplex — Communication that happens in two directions at the same time.

G.Lite — A communications standard sponsored by ITU that is used by ADSL.

Guard tone — A tone that an answering modem sends when it first answers the phone, to tell the calling modem that a modem is on the other end of the line.

Half-duplex — Communication between two devices whereby transmission takes place in only one direction at a time.

Handshaking — When two modems begin to communicate, the initial agreement made as to how to send and receive data. It often occurs when you hear the modem making noises as the dial-up is completed.

In-band signaling — In modem communication, the name of the signaling used by software flow control, which pauses transmission by sending a special control character in the same channel (or band) that data is sent in.

ISDN (Integrated Services Digital Network) — A communications standard that can carry digital data simultaneously over two channels on a single pair of wires, at about five times the speed of regular phone lines.

ITU (International Telecommunications Union) — The international organization responsible for developing international standards of communication. Formerly CCITT.

Line speed — *See* Modem speed.

Modem — From MOdulate/DEModulate. A device that modulates digital data from a computer to an analog format that can be sent over telephone lines, then demodulates it back into digital form.

Modem speed — The speed a modem can transmit data along a phone line measured in bits per second (bps). Two communicating modems must talk at the same speed for data transmission to be successful. Also called line speed.

Modem riser card — A small modem card that uses an AMR or CNR slot. Part of the modem logic is contained in a controller on the system board.

Modulation — Converting binary or digital data into an analog signal that can be sent over standard telephone lines.

Noise — An extraneous, unwanted signal, often over an analog phone line, that can cause communication interference or transmission errors. Possible sources are fluorescent lighting, radios, TVs, lightning, or bad wiring.

Out-of-band signaling — The type of signaling used by hardware flow control, which sends a message to pause transmission by using channels (or bands) not used for data.

Port settings — The configuration parameters of communications devices such as COM1, COM2, or COM3, including IRQ settings.

Port speed — The communication speed between a DTE (computer) and a DCE (modem). As a general rule, the port speed should be at least four times as fast as the modem speed.

RJ-11 — A phone line connection found on a modem, telephone, and house phone outlet.

Start bit — A bit that is used to signal the approach of data.

Stop bit — A bit that is used to signal the end of a block of data.

Telephony — A term describing the technology of converting sound to signals that can travel over telephone lines.

Telephony Application Programming Interface (TAPI) — A standard developed by Intel and Microsoft that can be used by 32-bit Windows 9x communications programs for communicating over phone lines.

Training — *See* Handshaking.

V.34 standard — A communications standard that transmits at 28,800 bps and/or 33,600 bps.

V.90 — A standard for data transmission over phone lines that can attain a speed of 56 Kbps. It replaces K56flex and x2 standards.

REVIEW QUESTIONS

1. How is communication over phone lines both direct and virtual? Give an example of each.
2. Converting a digital signal to analog is called ________________. Converting analog back to digital is called ________________.
3. Communication in only one direction at a time is ________________ communication. Communication in both directions at the same time is ________________ communication.
4. Why is the maximum transmission rate of today's modems limited to 56.6 Kbps?
5. How does the V.34 standard differ from the V.90 standard?
6. What two standards does the V.90 standard replace?
7. What organization is responsible for setting telecommunications standards?
8. Name two standards that pertain to data compression.
9. Why is a modem required to support more than one standard for transmission speed?
10. Name two reasons why a 56K modem might not transmit data at its maximum rated speed.
11. What happens when the receiving modem finds that the checksum is incorrect during data transmission with error checking?
12. On external modems, what is the purpose of the TD and RD lights?
13. Describe the difference between port speed and modem speed.
14. What chip controls a serial port?
15. When an external modem connects to a PC, what port is normally used? Describe the shape and name of the port connection.
16. During data transmission, what two devices can initiate a flow control message?
17. Why is hardware flow control better than software flow control?
18. Which two pins on a 9-pin serial cable are used for hardware flow control? What are these two pins called?
19. Why is it best to not have the UART chip perform parity checking?
20. What company invented the AT command set for a PC to communicate with a modem?
21. What is a dial-up, digital data transmission technology that is faster than regular phone lines?
22. Name two data-transmission technologies that offer a direct, "always up" connection.
23. List three hardware reasons why a modem might not respond.
24. List three software reasons why a modem might not respond.
25. Which is faster, an ISDN line or an ADSL line?

PROJECTS

Quick Modem Test

Use Windows HyperTerminal to make a call from your computer to any phone number. Describe what happens. What does this test confirm and not confirm about your modem and its setup?

Does Your Phone Line Qualify for a 56-Kbps Line?

You must have a V.34 standard modem for this project. Determine if your phone line is clean enough to support a 56-Kbps modem. Access the 3Com Web site at *www.3com.com*, search the site for "linetest", and follow the directions on the screen. Get a printed screen of your results.

Find Out About Your Modem

1. Open the Control Panel: Click **Start**, point to **Settings**, and click **Control Panel**.
2. Double-click **Modems**.
3. Click the **Diagnostics** tab.
4. Under Port, click the port that shows the installed modem.
5. Click the **More Info** button
   a. What DOS port does the modem use?
   b. What interrupt does the modem use?
   c. What port address does the modem use?
   d. What UART chip is used?
   e. What is the highest possible speed supported by the UART chip?
   f. What model of modem is installed?
   g. List several types of information stored under the Command and Response headings.
6. Click **OK**. Select the **General** tab, then click the **Dialing Properties** button. If you are using a business phone, how do you tell the computer what to do to access an outside line?

Change Your Modem's Connection Settings

Following the directions in the troubleshooting guidelines, change your modem's connection settings so that the modem speaker remains on the entire time that the modem is connected, by using the ATM2 command under the Extra settings box of Advanced Connection Settings.

Make a call with this setting. After you have finished the call, remove the extra setting.

Modem Troubleshooting

In the Advanced Connections Settings dialog box, check the box **Record a log file** for Windows 95 or **Append to Log** for Windows 98. This action causes Windows 9x to create a log file named Modemlog.txt in the folder where Windows is installed. Make a phone call using the modem and then disconnect. Print the log file that is created.

Simulating Modem Problems

Work with a partner on this project. Using a computer with an internal modem and a phone line, simulate a problem with the modem, as your partner does the same with another PC. Don't tell your partner what you did to your modem, and then exchange PCs. Troubleshoot the problem created by your partner. Here are some examples of problems to create:

- Change a jumper or DIP switch on the modem. (Don't do this without first carefully writing down the original setting.)
- Disable the COM port the modem is using.
- Uninstall the modem in the operating system.
- Loosen the modem card from its expansion slot.
- Disconnect the phone line.
- Insert the phone line in the wrong jack on the modem.

As you work to troubleshoot the problem caused by your partner, keep notes of what you discover and what you try. Begin by answering these questions:

1. Describe exactly what happens when you attempt to make a call.
2. List what you know works with the modem and the software.
3. List what you suspect the problem might be.
4. List the steps you take to correct the problem.
5. What was the source of the problem (not your partner!)?

Using Nuts & Bolts to Get Serial Port Information

Using Nuts & Bolts, access Discover Pro. From the Discover Pro main screen, click the **Diagnostics** tab, and then click **Advanced**. Select **Serial Diag** from the icons on the left side of the advanced diagnostics screen. Figure 16-30 is displayed. Perform the serial port test, and then print the test results. What does the term "external loopback" mean?

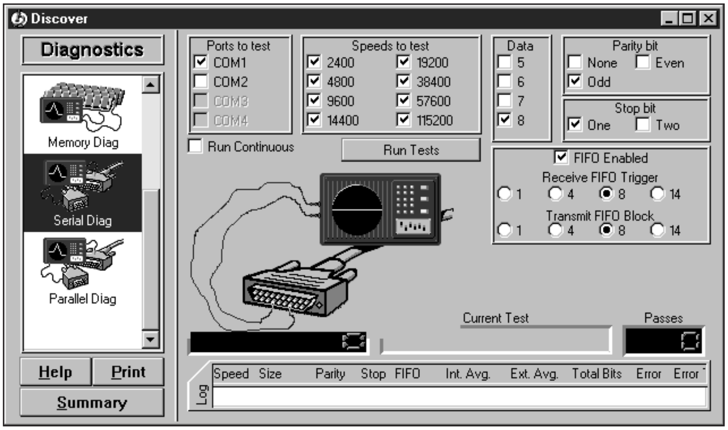

Figure 16-30 Nuts & Bolts advanced diagnostics can test a serial port

Cable Modem Research

Research what is involved for a cable modem connection to your home. Answer these questions:

1. Is the service available to your home?
2. How much does it cost?
3. What is provided with the service?
4. What equipment is needed that is not included with the service, and how much does it cost?
5. What software is required to use the service?
6. Does the company also serve as an Internet service provider?
7. Is transmission both upstream and downstream?

Research on the Internet

A customer asks you to install an ISDN TA device on his PC. Research how much the device costs, what features the device offers, and what software is included. Give the customer two options, one from 3Com and one from Eicon. Use their Web sites for your research. See *www.3com.com* and *www.eicon.com*.